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APRIL AND JULY 1973

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Aircraft sensors were selected to record the presence and characteristics of municipal and industrial wastewater discharges. The location and characteristics of detected discharges were compared with those of known discharges reported in Refuse Act Permit Program (RAPP) and National Pollutant Discharge Elimination System (NPDES) permit applications. Discharges from unknown sources that may have originated from nonfilers, and apparent additional or changed discharges at sources filing for permits were identified. The color, dispersion pattern and size of visible plumes for the observed discharges were documented.

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REMOTE SENSING REPORT

PACIFIC NORTHWEST AREA

WASHINGTON, OREGON, IDAHO

APRIL AND JULY 1973

National Field Investigations Center-Denver
Denver, Colorado
and
Region X, Seattle, Washington

September 1974

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GLOSSARY

°C -- Temperature in degrees Centigrade = 5/9 (°Farenheit -32)

cm -- Length in centimeters = 0.3937 inch or 0.03281 foot

km -- Distance in kilometers = 0.621 mile

km^2 -- Area in square kilometers = 100 hectares; 0.3861 square mile

l -- Volume in liters = 0.2642 gallon

m -- Length in meters = 3.281 feet or 1.094 yards

m^3 -- Volume in cubic meters = 264.2 gallons

m^3/day -- Flow rate in cubic meters per day = 0.000264 million gallons per day

m^3/sec -- Flow rate in cubic meters per second = 22.8 million gallons per day = 35.3 cubic feet per second

μm -- Micrometer

mm -- Length in millimeters = 0.1 centimeter

mm sq -- Area in square millimeters = 1.550 square inches

mrad -- Milliradian

IRLS -- Infrared Line Scanner

RAPP -- Refuse Act Permit Program

I. INTRODUCTION

Airborne remote sensing studies of five areas in the Pacific Northwest states of Washington, Oregon and Idaho (Puget Sound, Wash.; Grays Harbor, Wash.; Willamette River, Oreg.; Coeur D'Alene Lake, Idaho; and the Snake and Salmon Rivers, Idaho) were conducted in April and July 1973. These studies were undertaken at the request of the Permits Branch, Enforcement Division, Region X, EPA, Seattle, Wash. The scope and purpose of each investigation is summarized below.

PUGET SOUND, WASH.

Eight population and/or industrial centers in the Puget Sound area were investigated in both April and July. Aircraft sensors were selected to record the presence and characteristics of municipal and industrial wastewater discharges. The location and characteristics of detected discharges were compared with those of known discharges reported in Refuse Act Permit Program (RAPP) and National Pollutant Discharge Elimination System (NPDES) permit applicatons. Discharges from unknown sources that may have originated from nonfilers, and apparent additional or changed discharges at sources filing for permits were identified. The color, dispersion pattern and size of visible plumes for the observed discharges were documented. The geographical extent of each of the eight study areas* follows.

---

* An additional area, Port Angeles, Wash., was investigated to evaluate the dispersion of pulp and paper mill waste. The study is reported in "Remote Sensing Report, Port Angeles, Washington, April and July 1973," EPA National Field Investigations Center-Denver, Colo. and Region X, Seattle, Wash. (in preparation).

Bellingham Area

Cherry Point on the Strait of Georgia and Bellingham Bay.

Anacortes Area

Guemes Channel, Fidalgo Bay and southwestern Padilla Bay.

Port Townsend Area

Port Townsend Bay.

Everett Area

The Lower Snohomish River, Everett Harbor, Port Gardner and northeastern Possession Sound.

Seattle Area

The Lake Washington Ship Canal from Shilshole Bay (Puget Sound) to Lake Union, Elliott Bay, East and West Waterways, the Duwamish Waterway and the Lower Duwamish River.

Tacoma Area

Commencement Bay, the lower reach of the Puyallup River, and the Tacoma Harbor waterways.

Bremerton Area

Port Orchard, Port Washington Narrows and Sinclair Inlet.

Shelton Area

Oakland Bay

GRAYS HARBOR, WASH.

The upper reach of the Grays Harbor estuary in the vicinity of the cities of Hoquim and Aberdeen and the mouths of the Chehalis and Hoquim Rivers was investigated in late July to record and define the presence, magnitude and seepage of pulp and paper mill wastewaters from a lagoon on Rennie Island in the estuary.

WILLAMETTE RIVER, OREG.

A study of the lower Willamette River Valley between Salem and Portland was conducted in late July to document the physical location of non-point-sources of pollution to the Willamette River. Irrigation return flow drainage canals and other waterways were recorded and defined.

COEUR D'ALENE LAKE, IDAHO

This lake was investigated in late July to define the presence and areal extent of aquatic plant growths and algae.

SNAKE AND SALMON RIVERS, IDAHO

Segments of agricultural lands in the valleys of these two rivers were observed to define the presence of domestic animal feedlots close to the rivers. The Snake River area was flown in late April and the Salmon River area in late July. A complete inventory of feedlots in the form of annotated photographs was furnished to Region X.

II. SUMMARY

PUGET SOUND, WASH.

Bellingham Area

Wastewater discharges from two refineries and an aluminum plant were observed in the Cherry Point area of the Strait of Georgia. Numerous oil slicks were recorded at the Atlantic Richfield Company Cherry Point Refinery. A possible leak in an outfall or unreported discharge was detected at the Intalco Aluminum Corporation facility.

In Bellingham Bay, adjacent to the city of Bellingham, wastewater discharges from four food processing plants and a pulp and paper mill were observed. Also, five wastewater discharges of unknown origin and two oil slicks were detected. Bellingham Cold Storage was discharging wastewater to the Bay in July although the plant was scheduled to be connected to the municipal system by that date. Georgia Pacific Corporation reported eight wastewater discharges, several of which were inactive. In addition, two apparent unreported discharges were recorded.

Anacortes Area

In this area three food processing plants and a pulp and paper mill discharge wastewater to Guemes Channel. Two oil refineries and a wood products plant are on Fidalgo Bay. An unknown source in the vicinity of Northwest Fur Breeders west of Anacortes was discharging a large volume of a white substance that drifted westward about 1,830 m (6,000 ft) before dispersing. Oil slicks were detected in

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the vicinity of the Whitney-Fidalgo facility on Guemes Channel. Extensive oil slicks were present in the Anacortes Marina.

Port Townsend Area

An unknown outfall was detected near downtown Port Townsend. Oil slicks in the marina were recorded by the aircraft sensors. The Crown Zellerbach Corporation's kraft mill effluent was discoloring near-shore waters in the Glen Cove area.

Everett Area

Port Gardner, Everett Harbor, and the lower reach of the Snohomish River were investigated in this area. Weyerhaeuser Company operates a kraft mill and a sawmill on the lower reach of the Snohomish River. Effluents from these mills produced discoloration in the Snohomish River and adjacent Steamboat Slough. An oil slick was present in the river near the sawmill. Oil slicks were also detected in Everett Harbor in the vicinity of the Everett Plywood Corporation, Western Gear Corporation, and in a small marina. Scott Paper Company and the Weyerhaeuser Company operate sulfite pulp and paper mills discharging wastewaters to Port Gardner. Foam and visible discharge plumes were observed at both mills. An unreported discharge was recorded at the Weyerhaeuser mill. A foam tank on a subsurface diffuser was overflowing to Port Gardner at this mill.

Seattle Area

Numerous oil slicks were observed at six scattered locations in the Lake Washington Ship Canal. Two wastewater discharges from unknown sources were also detected.

Wastewater discharges to Elliott Bay from six seafood processing facilities and two shipyards were observed, as were two oil slicks near the seafood plants. Small oil slicks were also detected near discharges from both shipyards. A small discharge of unknown origin was detected to the west of the Lockheed shipyard.

Oil slicks and two discharges of unknown origin were detected in the East Waterway. Numerous oil slicks were also present in the Duwamish waterway. At the Ideal Cement Company mill, an apparent unreported discharge was detected.

Fifteen of the twenty-nine reported discharges were detected during the remote sensing flight.

Tacoma Area

Turbidity originating from the Puyallup River and the American Smelting and Refining Company at Ruston was discoloring much of Commencement Bay. The wastewater discharges from the Ruston smelter were producing extensive discoloration of near-shore waters. A surface bypass on a city of Tacoma sewer subsurface outfall was active near the smelter.

An oil slick was observed in City Waterway. The source appeared to be the Union Oil Company and Mobil Oil Corporation bulk petroleum products plants. A concrete mix plant was observed discharging truck washing wastewater to City Waterway. No permit application was submitted for this facility. A small discharge of unknown origin was observed at the southeast corner of the Wheeler-Osgood Waterway, a branch of City Waterway.

A discharge of unknown origin was recorded at the south end of Sitcum Waterway. At the Domitar Chemical, Inc. lime facility on Blair

Waterway, there were indications of significant leaching for raw materials stockpiles. The surface waters in the turning basin of Blair Waterway were significantly warmer than the rest of the waterway. The source of a thermal discharge was not determined. Three discharges of unknown origin to Hylebos Waterway were detected. Eleven of the ninteen reported discharges were detected.

Bremerton Area

The Puget Sound Naval Shipyard is on Sinclair Inlet at Bremerton. No discharges were visible from the facility's reported 17 outfalls. However, an oil slick was recorded in the vicinity of an aircraft carrier.

Shelton Area

Wood products plants operated by Simpson Timber company and ITT Rayonier discharge wastewaters to Oakland Bay at Shelton. The bay was heavily discolored. Three unreported wastewater discharges were observed.

GRAYS HARBOR, WASH.

The upper portion of the Grays Harbor estuary was investigated to define the presence of wastewater discharges and seeps from a lagoon on Rennie Island serving the ITT Rayonier pulp and paper mill. Also, pollution dispersion patterns from these discharges were recorded. Two pipe outfalls, two open ditch outfalls and numerous seeps were observed. No significant discoloration attributable to these discharges was recorded.

WILLAMETTE RIVER, WASH.

Numerous non-point-sources of pollution to the Willamette River in the form of irrigation return flow drainage canals and other small watercourses were recorded in the Willamette Valley between Salem and Portland. This area is fertile agricultural land.

COEUR D'ALENE LAKE, IDAHO

This lake was investigated to define the presence and areal extent of algae and aquatic plant growths. No significant concentrations of algae were detected in open lake waters. Aquatic plant growths were recorded in several of the tributary arms and backwater bays of the lake.

SNAKE AND SALMON RIVERS, IDAHO

The locations of hundreds of domestic animal feedlots in the agricultural valley lands adjacent to the Snake, Boise and Payette Rivers in southern Idaho were documented. No feedlots were observed along the middle reach of the Salmon River in central Idaho.

III. STUDY TECHNIQUES

AIRCRAFT AND FLIGHT DATA

Four high-performance aircraft were used in the remote sensing flights over the Pacific Northwest. Specially designed for aerial reconnaissance work, each plane was equipped with different camera films and filters to fulfill a specific purpose in the study as described below.

The flight parameter data shown in Table III summarize the variables important at the time of flight and during the analysis of the airborne data. The airspeed variations are automatically entered in the aircraft computer system, combined with aircraft altitude, and used to calculate the amount of photographic stereo overlap.

SENSOR DATA

The sensors installed in each aircraft were three cameras and an infrared line scanner.

Cameras

The cameras on three of the aircraft were KS-87B aerial framing cameras equipped with 152 mm (6 in.) focal length lens assemblies. They were mounted in vertical position at the three camera stations shown in Figure III-1. In the fourth aircraft, KS-87B aerial framing cameras (152 mm lens assemblies) were positioned at Stations 1 and 2 and a T-11 framing camera was at Station 3.

The T-11 uses 241 mm (9.5 in.) film which gives a 229 mm sq (9 in. sq) format. This camera covers four times as much ground surface as the KS-87B.

TABLE III

FLIGHT PARAMETER DATA

[Nominal aircraft airspeed was 666 km/hr (360 kn).]

Study Area	Flight Date and Time		No. of Aircraft	Altitude Above Water or Ground Level		No. of Sensors		
				(meters)	(feet)	KS-87B	T-11	IRLS[a]
April		(PST)[b]						
Puget Sound								
Bellingham-Everett	4-25-73	1310-1412	2	915	3,000	6		2
Port Susan-Everett		1620-1740	1	7,000	20,000		1	1
Tacoma-Everett		1620-1740	1	7,000	20,000		1	1
Bremerton-Tacoma		1700-1740	2	915	3,000	6		2
Everett-Tacoma	4-26-73	1030-1138	2	915	3,000	6		2
Snake River		1000-1100	1	7,000	20,000		1	1
July		(PDT)[c]						
Puget Sound								
Bellingham-Everett	7-24-73	1150-1310	2	915	3,000	6		
Everett-Tacoma		1650-1715	2	915	3,000	6		
Willamette River		1400-1540	1	915	3,000		1	1
Grays Harbor		1530-1550	1	915	3,000		1	1
Puget Sound	7-26-73	1210-1300	1	12,000	40,000	3		1
Coeur d' Alene Lake and Salmon River		1140-1250	1	3,050	10,000		1	1

---

a/ Infrared Line-Scanner b/ Pacific Standard Time c/ Pacific Daylight Time

The viewing angle was 41° for the KS-87B framing cameras and 74° for the T-11 cameras, centered at the lowest point of the aircraft [Fig. III-2].

Films and Filters

The KS-87B cameras on two aircraft were loaded with these film and optical filter combinations:

Camera Station 1--Kodak SO-397 Aerographic Ektachrome Film (127 mm) with a Wratten HF-3/HF-5 gelatin optical filter combination. The film provides a true color transparency 114 mm sq (4.5 in. sq). The filter combination prevents ultraviolet light from reaching the film and eliminates the effects of atmospheric haze.

Camera Station 2--Kodak 2402 plus-X Aerographic Film (127 mm) with a Wratten 39 glass optical filter. This film-filter combination provides a black/white negative, having been exposed to near-ultraviolet and deep-blue optical energy. This sensor was primarily used for the detection of oil slicks.

Camera Station 3--Kodak 2443 Aerochrome Infrared Film (127 mm) with a Wratten 16 gelatin optical filter. The film provides color transparencies 114 mm sq.

In contrast to the more familiar true color film, the Kodak 2443 film presents modified color, or false color, in the processed transparency. Whereas the true color Ektachrome film has a red, green, and blue sensitive emulsion layer, the Kodak 2443 film emulsion layer is sensitive to the near-infrared as well as red and green*. The modified or false color occurs when the exposed image on the infrared film is processed.

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* Every color film has various combinations of red, green and blue dyes similar to the red, green and blue dots on the front of a color television picture tube.

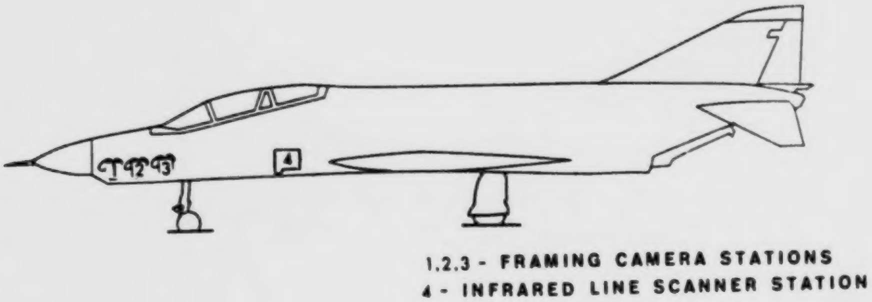
1
2
3
4
1,2,3 - FRAMING CAMERA STATIONS
4 - INFRARED LINE SCANNER STATION

Figure III-1. Aircraft Sensor Locations

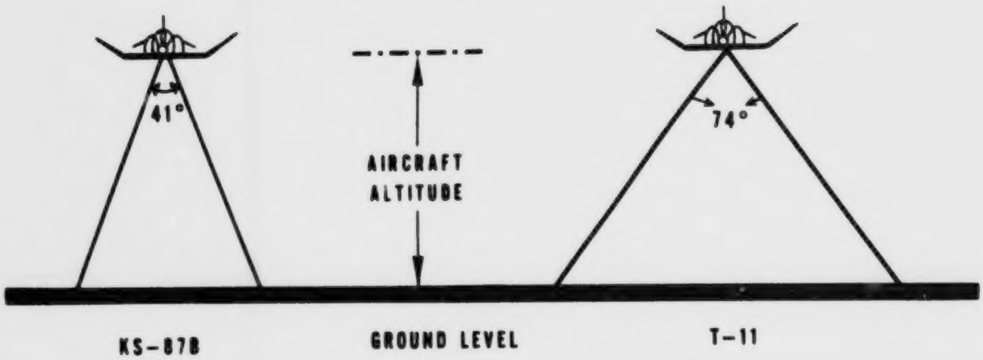
41°
AIRCRAFT
ALTITUDE
74°
KS-87B
GROUND LEVEL
T-11

Figure III-2. Viewing Angle of the Framing Camera

The Wratten 16 filter, a deep orange color, transmits a portion of the visible optical spectrum (deep green, yellow, orange, and red) with the near-infrared energy from 0.7 to 1.0 µm. It keeps all blue light from reaching the film and thus prevents an unbalance in the normal red, green, and blue colors.

In the finished transparency, trees, plants, and algae produce infrared exposure and appear red, while red and green objects appear green and blue, respectively. The false color rendition of this film-filter combination greatly eases the task of locating surface water since foliage is shown as red and water as blue.

The most important asset of the Kodak 2443 film is its capacity to record the presence of various levels of chlorophyll in terrestrial and aquatic plant growth. Leaves on a healthy tree will appear bright red rather than the usual green, and unhealthy foliage looks brownish-red.

The KS-87B framing cameras on the third aircraft were loaded with these film and optical filter combinations:

Camera Station 1--Kodak S0-397 Aerographic Ektachrome Film (127 mm) with a Wratten 58 (green) gelatin optical filter, resulting in a color transparency exposed to the green region of the optical spectrum.

Camera Station 2--Kodak S0-397 Aerographic Ektachrome Film (127 mm) with a Wratten 25 (red) gelatin optical filter, resulting in a color transparency exposed to the red region of the optical spectrum.

Camera Station 3--Kodak 2443 Aerochrome Infrared Filter with a Wratten 89B infrared optical filter, producing a red transparency that contains the infrared optical information reflected from a particular target area.

The two KS-87B framing cameras and a T-11 camera on the fourth aircraft were as follows:

Camera Station 1--KS-87B camera with Kodak 2443 Aerochrome Infrared Film (241 mm) with a Wratten 16 (orange) optical filter. This station was used as backup for the T-11 camera at Station 3.

Camera Station 2--Spare camera, not loaded.

Camera Station 3--T-11 framing camera with Kodak 2443 Aerochrome Infrared Film (241 mm) with a Wratten 16 (orange) optical filter. This camera was used to map the feed lots in Idaho, the non-point-source water to the Willamette River in Oregon, and in portions of the high altitude reconnaissance over Puget Sound.

Infrared Line Scanner

Each aircraft was equipped with an AN/AAS 18 Infrared Line Scanner located on the underside of the aircraft [Fig. III-1]. The IRLS image area is along the flight path of the aircraft. The width of the image area depends on the aircraft altitude; the area is encompassed by a 120° field-of-view in crosstrack, or perpendicular to the flight path [Fig. III-3].

An IRLS converts variations in infrared energy emissions from objects of different temperatures into a thermal map. The three basic parts of an IRLS are the scanner optics, a detector array, and a recording unit. The scanner optics collect the infrared emissions from ground and water areas and focus them on the detector [Fig. III-4].

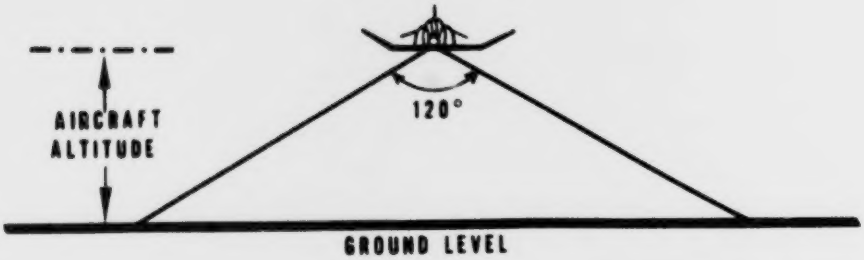
AIRCRAFT
ALTITUDE
120°
GROUND LEVEL

Figure III-3. Field of View of Infrared Line Scanner

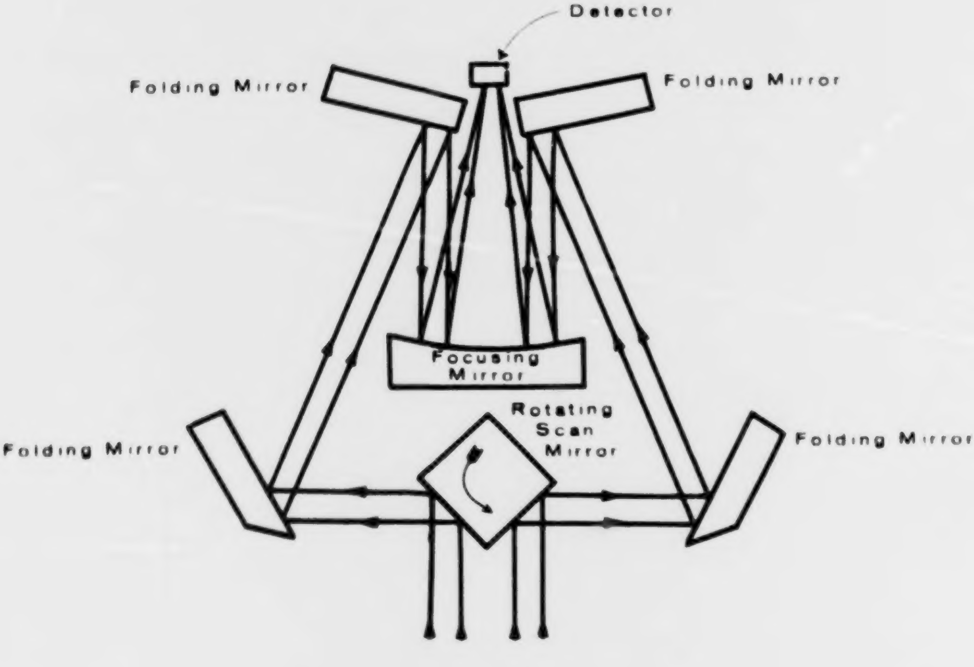
Detector
Folding Mirror
Folding Mirror
Focusing Mirror
Rotating Scan Mirror
Folding Mirror
Folding Mirror

Figure III-4. Incident Infrared Energy

The detectors, cryogenically cooled to 26° K, convert the infrared energy collected by the scanner optics into an electronic signal. This signal is processed electronically and subsequently transformed into visible light through a cathode ray tube. This light is then recorded on ordinary 126 mm (5 in.) RAR black/white film. The recorded thermal map is 100 mm (4 in.) wide, and its length depends on the length of a particular line of flight being imaged.

The IRLS has a sensitivity bandwidth from 8 to 14 μm, the so-called thermal band of the electromagnetic spectrum, representing temperatures from -66°C to 89°C. The system has an instantaneous field-of-view of 1 mrad sq. The total field-of-view is achieved by the rotating mirror in the optical collection system, which is 120° by 1 mrad. The measured noise equivalent temperature of the IRLS is 0.32°C with 100 percent probability of target detection. This represents an effective measurement of the temperature resolution of the system.

The spectral sensitivity data for each film, and the optical filter transmittance curves are shown in Appendix A. Development processes for each type of film are described in Appendix B. Appendix C explains aerial sensors in respect to focal length, angle of view, and the effects of focal length and altitude on scale and ground coverage.

DATA INTERPRETATION AND ANALYSIS

All data interpretations and analyses were made on the original photographic and infrared line scanner films, since photographic prints of transparencies distort scale and color balance. The original films are true color transparencies, false color infrared transparencies, black/white ultraviolet negatives, and the IRLS thermal image black/white negatives.

Standard image analysis techniques were used to reduce the aerial reconnaissance data, which include the physical measurements of distances and areas, and stereoscopic analysis of areas displaying topographic gradients on land and in water.

The reduced data were plotted on U. S. Geological Survey 7.5-minute topographic maps (scale 1:24,000) and U. S. Coast and Geodetic Survey Nautical Charts (Scale 1:15,000). All photographs and thermal maps in this report show scale. To evaluate scale consistency, the map scales were compared to the imagery empirical scales, which were derived from the optical focal length of each sensor and the altitude of the aircraft above water level [Appendix C].

In the black/white IRLS film, temperature levels are represented by shades of gray in the negative, or rendition. Cool temperatures appear as clear film or low-density gray, while increasingly higher temperatures appear as higher density gray. Positive prints presented in this report reflect the reverse of the negative film; cool areas are dark and warm areas are light gray.

It is important to remember that the IRLS will only record water surface temperatures, since water is opaque in this region of the infrared spectrum. The maximum penetration in either fresh or salt water is

0.01 cm. Therefore, a submerged thermal discharge can be detected from an aircraft with IRLS only if the warm wastewater reaches the surface of the receiving body of water. The isothermal maps developed by this study thus represent surface temperatures only and do not necessarily reflect subsurface temperature distributions.

ERROR ANALYSIS

Limitations can be placed on the accuracy or uncertainty of the film analysis measurements from the photographic and thermal data. Measurements for linear distance and surface area were made with scaling instruments and light table microscopes.

The uncertainty for linear distance (ΔLD) is:

$$\Delta LD = \pm 2 \times 10^{-4} \times \text{photographic scale (meters)} \qquad (1)$$

The photographic scale for most of the Puget Sound imagery was 1:5,000. The value for $\Delta LD = (\pm \times 10^{-4} \text{ X } 5{,}000) \text{ m} = \pm 1 \text{ m}$. A distance X, measured on the original photographic film, is accurate to within ± 1 meter.

The uncertainty for the surface area (ΔSA is rectangular) is:

$$\Delta SA = \pm \Delta LD \, (X + Y) \qquad (2)$$

For this study area $\Delta SA = (\pm X \pm Y) \text{ m}^2$, $(\Delta LD = \pm 1 \text{ m})$.

For example, a rectangular area with dimensions of $X \pm 1$ m and $Y \pm 1$ m would have the value $[XY + (\pm X \pm Y)] \text{ m}^2$.

The uncertainty in the IRLS is the measured system noise equivalent temperature which is ± 0.32° C. Since no ground truth was taken at the time of flight, no terrestrial instrumentation uncertainty entered the analysis.

No atmospheric corrections were applied to the reconnaissance data. It was assumed that the atmospheric effect was constant through the air column between the aircraft and the water during the short duration of each flight. For the most part, the data was used for qualitative analysis only, due to the lack of ground truth.

IV. RESULTS OF INVESTIGATION
PUGET SOUND AREA, WASH.

GENERAL DESCRIPTION OF AREA

Puget Sound is the dominant feature of a complex system of waterways in northwestern Washington [Fig. IV-1]. This large marine waterway has a surface area of about 6,400 km^2 (2,500 mi^2). Numerous bays, inlets, straits and channels serve to dissect the terrain into islands and peninsulas.

Puget Sound is connected to the Pacific Ocean by the Strait of Juan de Fuca, a large marine waterway. The Strait of Georgia, a large fjord fed by the Fraser River in Canada, lies to the north of Puget Sound. A large tidal range and strong tidal currents characterize the waterways of this area. Large seasonal fluctuations in freshwater inflow to both Puget Sound and the Strait of Georgia also occur. The combination of tidal effects and fluctuating freshwater inflows exert a major influence on water quality throughout the system. In most cases water quality is excellent. In confined bays and estuaries adjoining industrial areas, however, water quality problems have occurred. These problems have historically been most severe near pulp and paper mills.

The Puget Sound waterway system provided the basis for development of industrial and population centers at scattered points favorably situated for the movement of raw materials and finished products by water. The wood products industry, including sawmills and pulp and paper mills, have capitalized on this low cost means of transportation.

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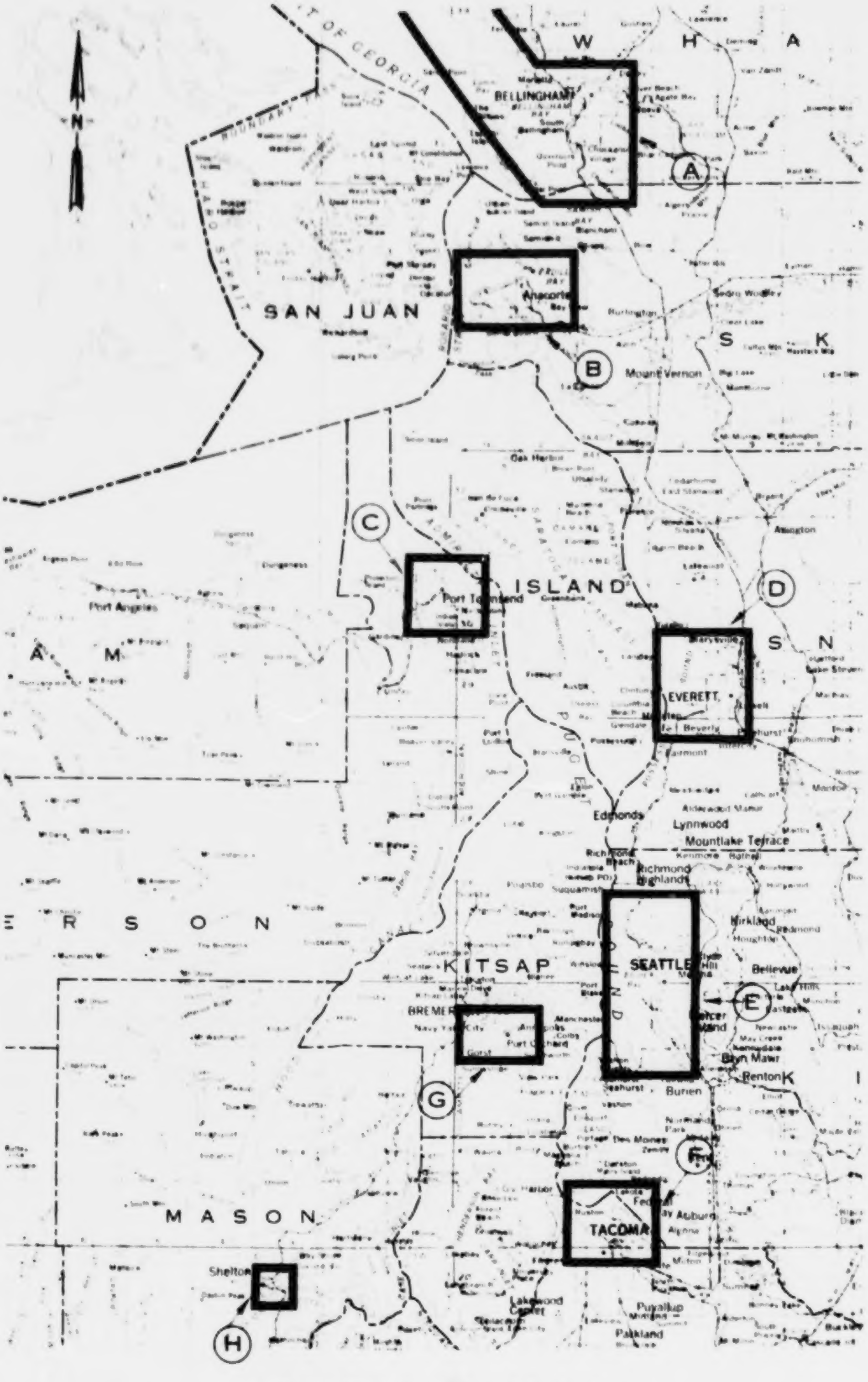

N
STRAIT OF GEORGIA
W H A
BELLINGHAM
A
SAN JUAN
Anacortes
B
Mount Vernon
S K
Oak Harbor
C
Port Townsend
ISLAND
Port Angeles
D
EVERETT
S N
A M
Edmonds
Lynnwood
Mountlake Terrace
Richmond Highlands
E R S O N
KITSAP
SEATTLE
Kirkland
Bellevue
E
BREMERTON
Port Orchard
Renton
G
Burien
Des Moines
F
Auburn
MASON
TACOMA
Shelton
H
Puyallup
Parkland

Figure IV–1. Puget Sound Study Areas

The population of the Puget Sound area is more than 2,000,000, primarily located in the Seattle-Tacoma metropolitan area. Other population centers are Anacortes, Bellingham, Everett, Bremerton, Port Angeles, Olympia and Shelton; this study includes all of these areas except Olympia and Port Angeles.

The following sections present a more detailed description of the eight study areas in the Puget Sound region and summarize the results of the remote sensing studies.

BELLINGHAM (AREA A)

Description of Area

Two hydrologically separate areas were investigated in the Bellingham vicinity. The Cherry Point - Neptune Beach area is located on the east shore of the Strait of Georgia about 16 km (10 mi) west-northwest of Bellingham [Fig. IV-2]. Two oil refineries and an aluminum plant are on a 6 km (4 mi) section of this shoreline. The population density of the adjacent area is low. The Strait of Georgia is wide and deep at this location. Water depths in excess of 55 m (180 ft) occur several kilometers offshore; water depths of 18 m (60 ft) occur within 0.7 to 1.0 km (0.4 to 0.6 mi) of shore. No significant freshwater inflow occurs in the immediate vicinity.

The second area investigated was the eastern portion of Bellingham Bay in the Bellingham urban area. Bellingham, Samish and Padilla Bays form an oceanographic unit about 30 km (19 mi) long and 8 km (5 mi) wide that is hydrologically separated from the Strait of Georgia by several islands. Surface water quality in Bellingham Bay is strongly influenced by the inflow from the Nooksack River which enters the Bay at the north end. This inflow averages 105 m^3/sec (3,700 cfs). Water depths in the Bellingham vicinity reach 18 m (60 ft) about 1 km (0.6 mi) offshore.

The population of Bellingham and its environs is about 40,000. In addition to the municipal waste treatment facility, known waste discharges originate from a large pulp and paper mill and several food processing plants.

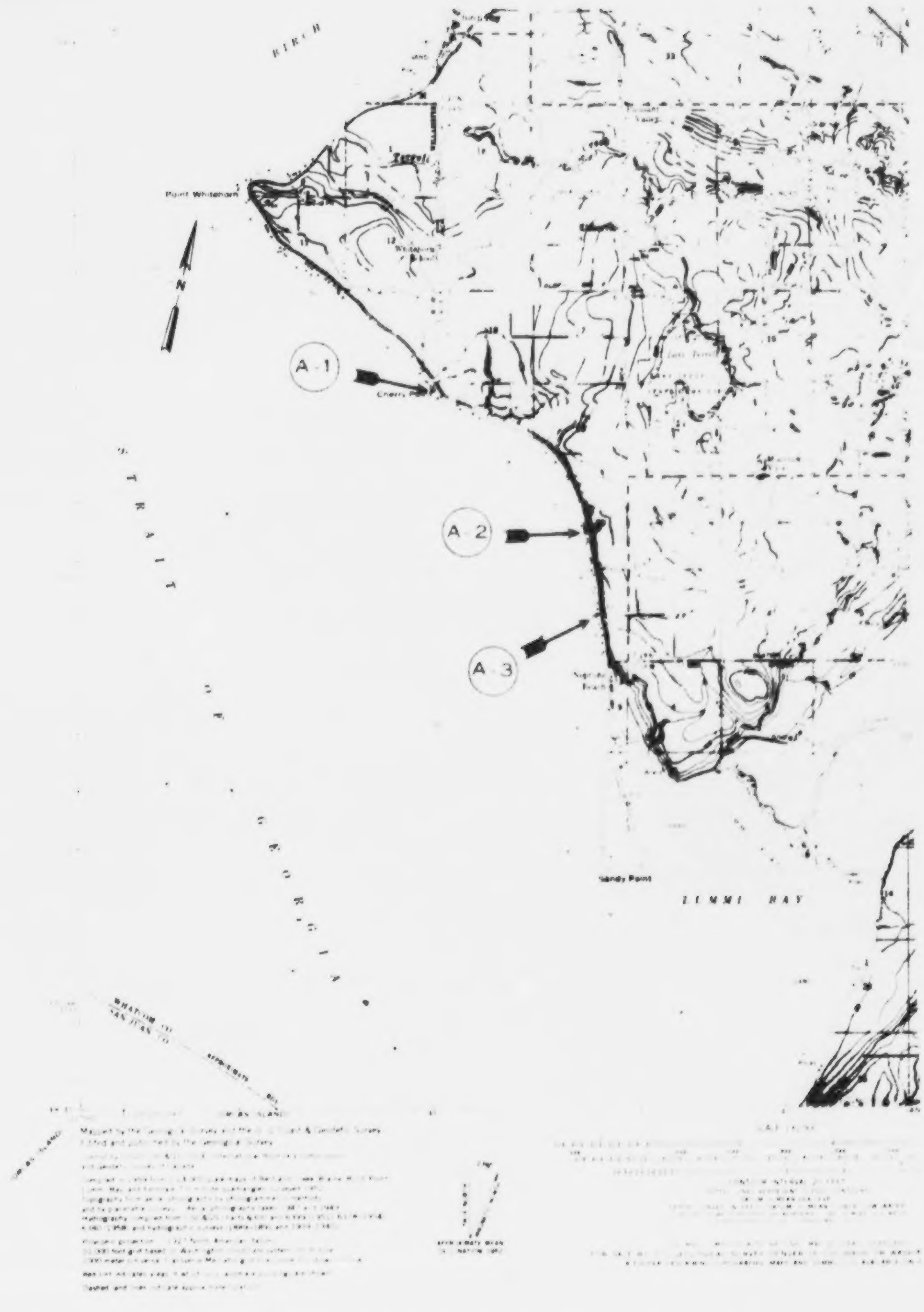

BIRCH
Point Whitehorn
N
A-1
Cherry Point
A-2
A-3
STRAIT OF GEORGIA
Sandy Point
LUMMI BAY

Figure IV–2. Cherry Point – Neptune Beach Area

General Observations

In the vicinity of Cherry Point, the water was gray-green, typical of the appearance of the Strait of Georgia. Kelp beds near shore were clearly visible.

The northern portion of the area of Bellingham Bay investigated was also gray-green. In the main harbor area, however, the water was dark green. Numerous log rafts, pilings and dolphins were observed throughout the harbor area.

Specific Observations - Cherry Point-Neptune Beach Area

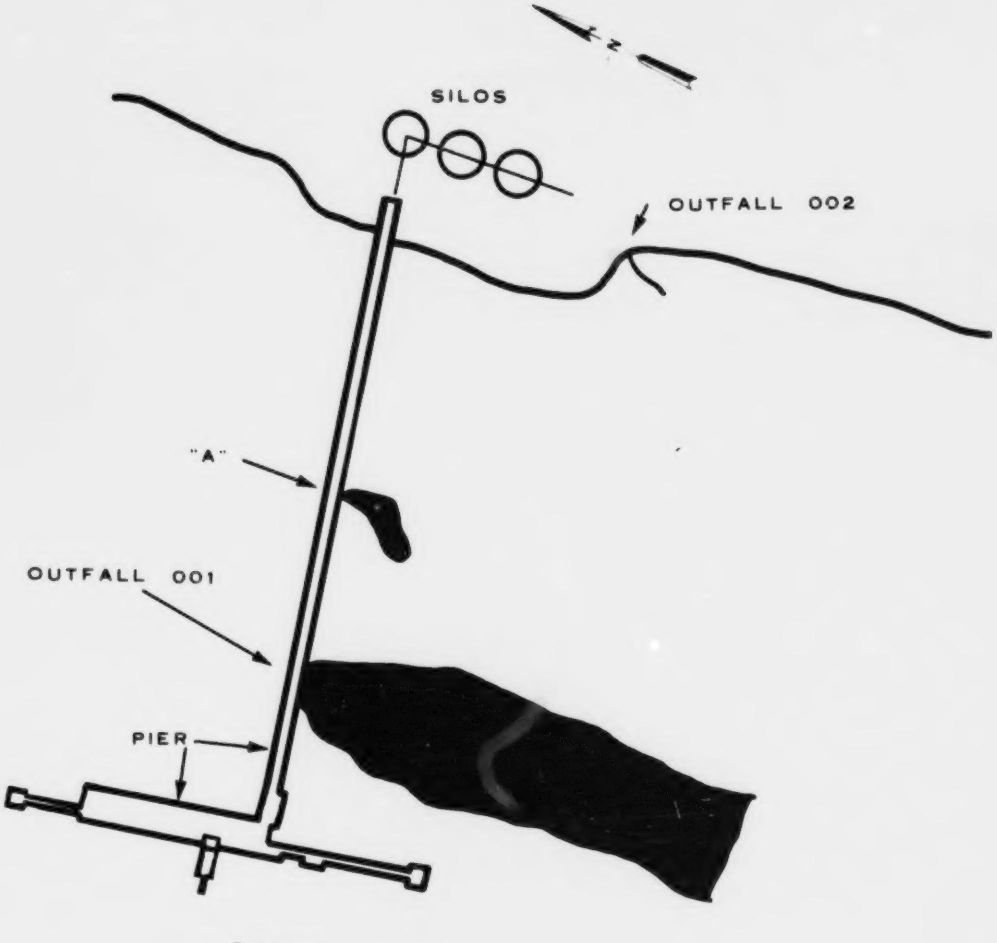
A-1 Cherry Point Refinery, Atlantic Richfield Company [3-001]*--The refinery reportedly discharges 24,600 m^3/day (6.5 mgd) of cooling water, boiler blowdown, and process and sanitary wastewater to the Strait of Georgia through a submerged diffuser on their dock about 700 m (2,300 ft) offshore in 18 m (60 ft) of water [Fig. IV-2]. Aerial imagery of the actual outfall position was not obtained. However, numerous oil slicks were observed in the immediate area.

A-2 Intalco Aluminum Corporation [3-056]--Two outfalls were reported by this installation. Outfall 001 discharges 57,000 m^3/day (15 mgd) of cooling water and process wastewater to the Strait of Georgia from a point on the pier about 270 m (900 ft) offshore [Fig. IV-3]. Outfall 002 is a storm drain discharging at the shoreline.

In April, a yellow-brown plume was originating from Outfall 001 and was dispersing southward for 150 m (500 ft). The extent of the

---

*A coded form of the Refuse Act Permit Program application number will be used throughout this report. The code [3-001] refers to application number 071-OYB-3-000001. The underlined numbers are the code. The other letters and numbers are the same for all application numbers in this report.


N
SILOS
OUTFALL 002
"A"
OUTFALL 001
PIER
STRAIT OF GEORGIA

"A" THIRD OUTFALL OR POSSIBLE
LEAK TO OUTFALL 001

Figure IV-3. Intalco Aluminum Corporation Discharges

plume and relative levels of discoloration are shown in Figure IV-3, with the area labeled "1" the most discolored. Outfall 002 was inactive. At point "A" on the pier, a small yellow-brown plume 2 m (6 ft) wide and 11 m (35 ft) long was dispersing southward indicating the presence of a third outfall or a leak in the pipeline to Outfall 001.

The July imagery included only Outfall 002 and point "A". No activity was recorded in the area of Outfall 001. An aerated lagoon on shore to the south of the pier [Fig. IV-4] was noted that was not reported in the RAPP application. A refuse area similar in color to the lagoon contents lay between the lagoon and the shoreline; there were indications of seepage from the lagoon to the Strait.

A-3 Ferndale Refinery, Mobil Oil Corporation [3-060]--Cooling water, boiler blowdown, and process wastewater averaging 8,700 m^3/day (2.3 mgd) are discharged from this facility to the Strait of Georgia through Outfall 001 located about midway out on the pier [Fig.IV-5].

Both the April and July flights recorded a visible plume originating from this outfall. In April the plume extended 370 m (1,200 ft) southward [Fig. IV-5] with the tide in the ebb phase. In July the plume extended 240 m (780 ft) northward during flood tide.

Specific Observations - Bellingham Bay

A-4 Columbia Cement Company [2-097]--Aerial imagery was not recorded in this area of Bellingham Bay [Fig. IV-6]. The plant reportedly discharges 1,400 m^3/day (0.37 mgd) of cooling and process wastewater through two outfalls.

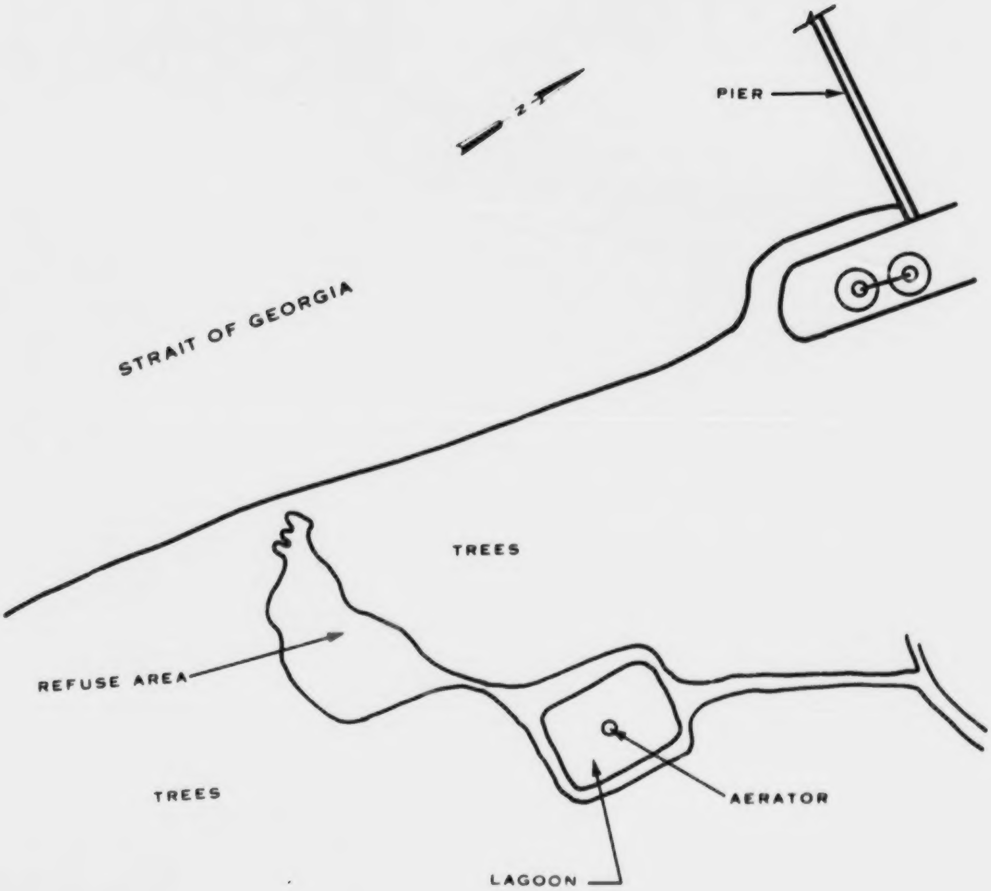

N
PIER
STRAIT OF GEORGIA
TREES
REFUSE AREA
TREES
AERATOR
LAGOON

Figure IV-4. Intalco Aluminum Corporation Lagoon

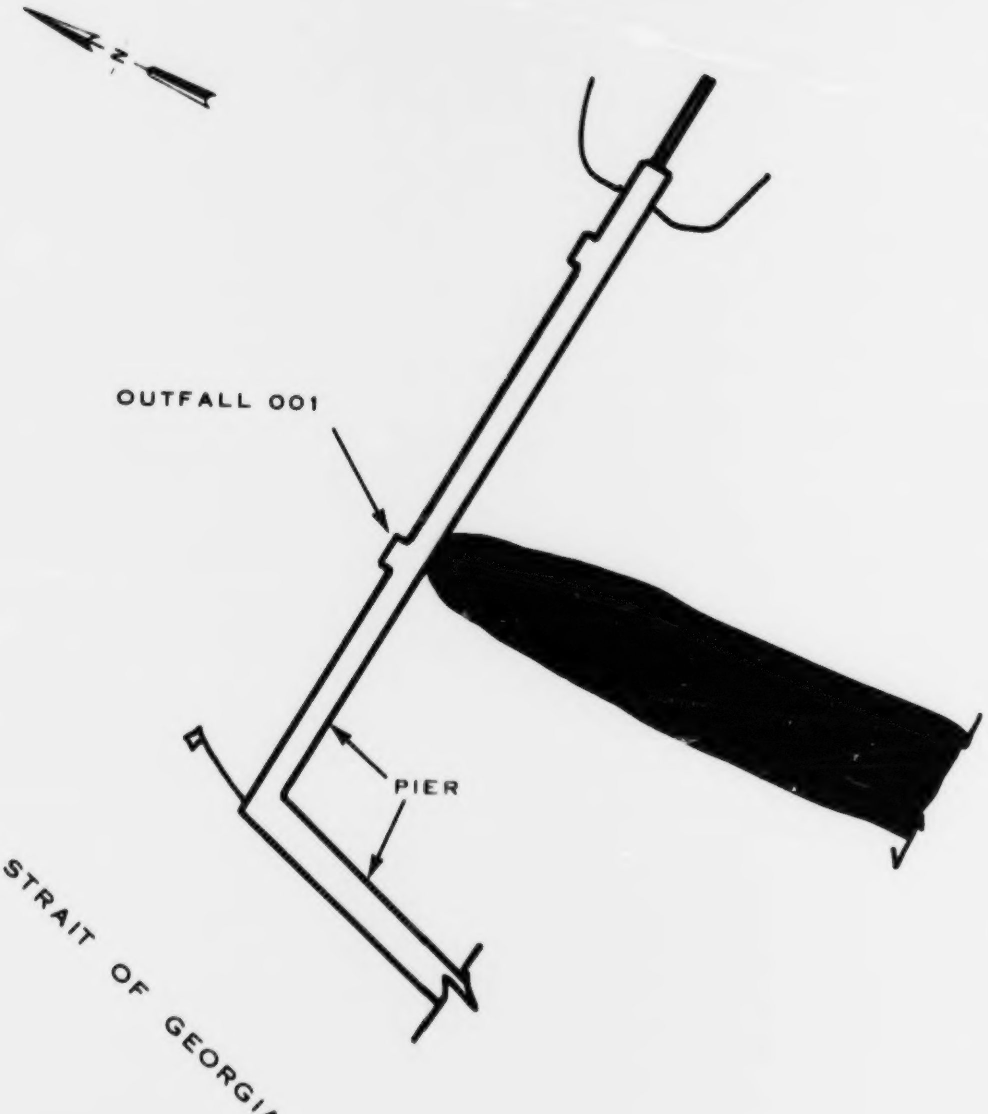

N
OUTFALL 001
PIER
STRAIT OF GEORGIA

Figure IV–5. Mobil Oil Corporation Discharge

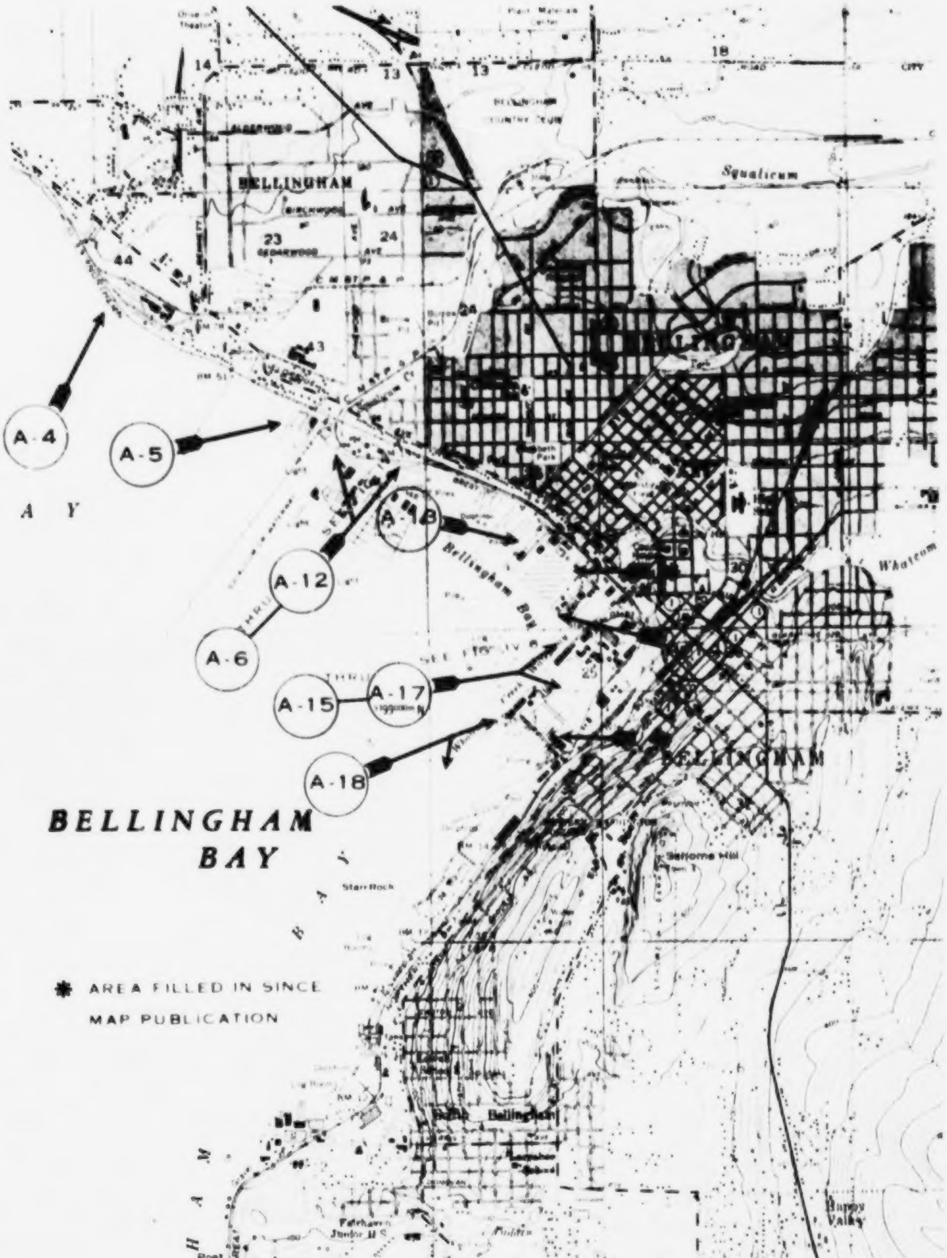

A-4
A-5
A-18
A-12
A-6
A-15
A-17
A-18
BELLINGHAM BAY
BELLINGHAM
Bellingham Bay
Squalicum
Whatcom
Post Point
Fairhaven
Chuckanut Village
Edgemoor
Sehome Hill
✱ AREA FILLED IN SINCE MAP PUBLICATION

Figure IV–6. Bellingham Bay Area

A-5 Unidentified Outfall--A yellow-green plume 18 m (60 ft) long was recorded at this location [Fig. IV-6 and IV-7] in July, indicating the presence of an active outfall. Aerial imagery was not recorded for this area in April.

A-6 Lynden Umitilla Foods [2-215]--Cooling and process wastewater averaging 4,000 m^3/day (1.15 mgd) is discharged from this plant into Squalicum Creek Waterway. A yellow-brown plume 37 by 180 m (120 by 600 ft) was observed dispersing southward in the waterway in July. This area was not imaged in April.

A-7 Bellingham Cold Storage [2-252]--This plant reported three outfalls in 1971. All three discharges were to be connected to the municipal sewerage system by July 1973. In July, however, a moderate-sized white plume indicated the presence of a discharge from Outfall 001. The discharge was reported by the RAPP application as cooling and process water. No discharge was detected from Outfalls 002 and 003.

A-8 Vita Food Products [2-187]--Two outfalls reportedly batch discharge about 34 m^3/day (0.009 mgd) of process wastewater from this facility at the dock face [Fig. IV-7]. This area was imaged only in July. Both outfalls were active, creating two distinct white foam plumes that combined and drifted southeastward for 76 m (250 ft) along the dock face before dispersing.

A-9 Bumble Bee Seafoods [3-005]--A slight discoloration was observed in the vicinity of Outfall 002 in July [Fig. IV-7]. No discharge was detected at Outfall 001 located on the breakwater. These two outfalls reportedly discharge a total of 1,170 m^3/day (0.31 mgd).

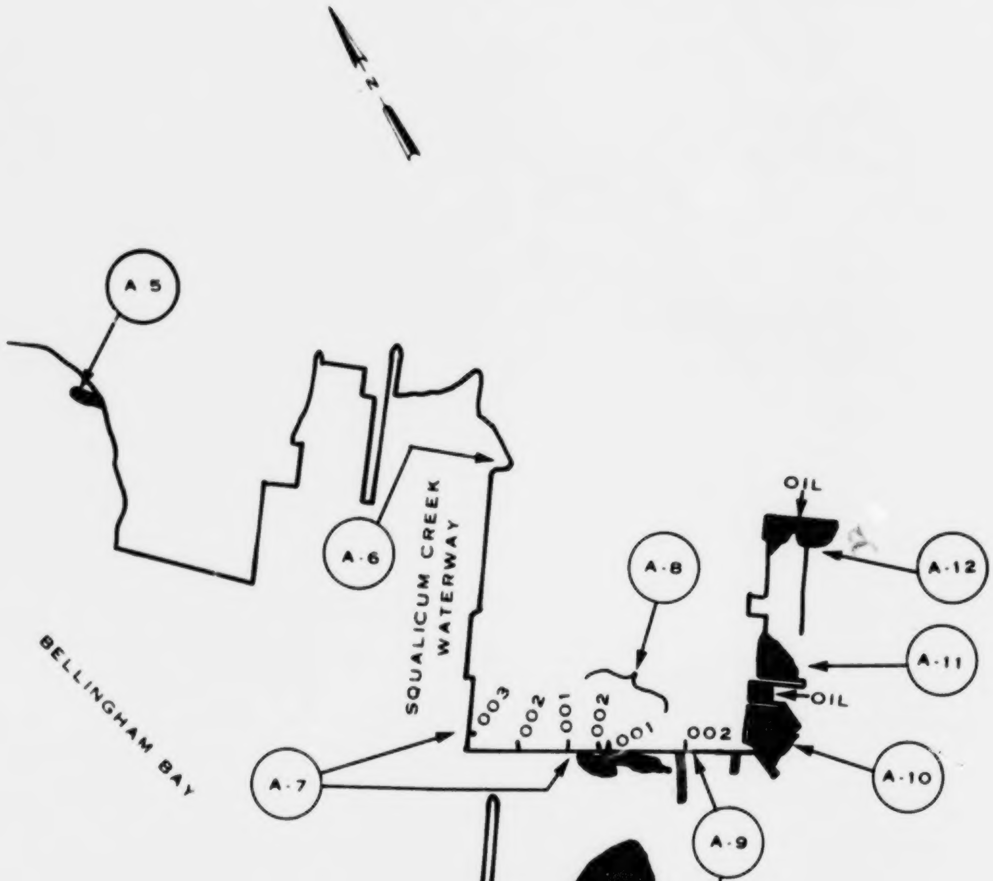

N
A-5
A-6
SQUALICUM CREEK WATERWAY
OIL
A-12
A-8
A-11
OIL
BELLINGHAM BAY
003
002
001
002
001
002
A-10
A-7
A-9
001
BREAKWATER

Figure IV–7. Squalicum Creek Waterway Area

An oil slick containing about 15 liters (4 gal.) of oil was located on the inside of the breakwater.

A-10 Oil Slick--An oil slick containing about 19 liters (5 gal.) of oil and discoloration of surface water was observed at this location [Fig. IV-7].

A-11 Unknown Discharge--In July a yellow-brown plume, 27 X 37 m (90 X 120 ft), was recorded indicating the probable presence of a discharge. No surface disturbance was observed suggesting that the source originated under the wharf. An oil slick containing about 11 liters (3 gal.) of oil was present.

A-12 Oil Slick--A small oil slick containing 8 liters (2 gal.) of oil was recorded in this area. There was no visible indication of a discharge.

A-13 Surface Runoff--A yellow-gray plume 30 m (100 ft) long originated at this position [Fig. IV-7]. The discharge appeared to be surface runoff.

A-14 Storm Drain--A large pipe with an estimated diameter of 0.9 m (36 in.) terminates at water level at this location [Fig. IV-8]; it was presumed to be a storm drain. No discharge was observed.

A-15 Unknown Discharge--Yellow-brown wastewater was flowing as runoff from two ponds into Whatcom Creek Waterway [Fig. IV-8]. The resultant plume dispersed quickly in the waterway.

A-16 Unknown Outfall--A small above-surface outfall was discharging into Whatcom Creek Waterway in July, creating a small yellow-gray plume [Fig. IV-8].

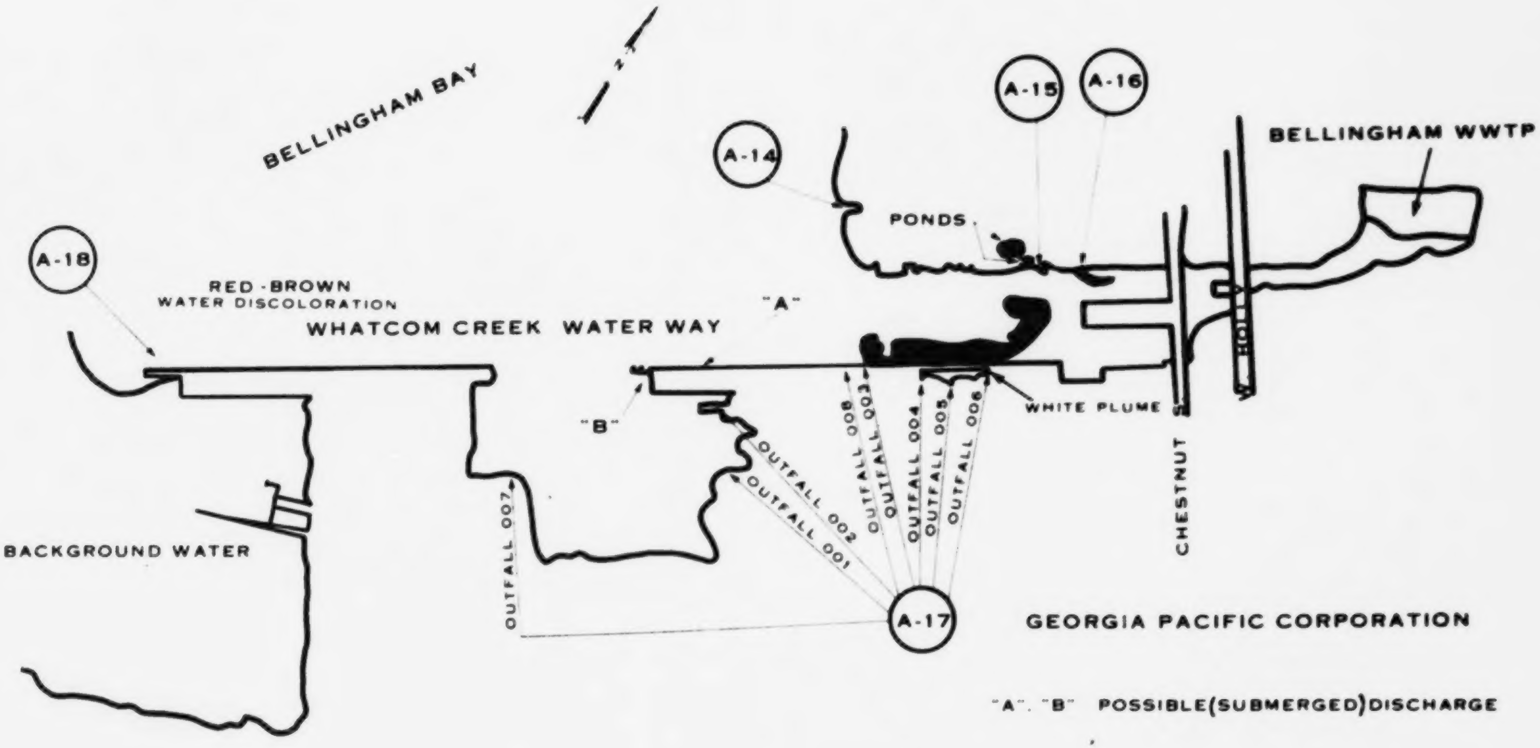

BELLINGHAM BAY
N
A-14
A-15
A-16
BELLINGHAM WWTP
PONDS
A-18
RED-BROWN
WATER DISCOLORATION
WHATCOM CREEK WATER WAY
"A"
"B"
W. HOLLY
CHESTNUT S
WHITE PLUME
OUTFALL 001
OUTFALL 002
OUTFALL 003
OUTFALL 004
OUTFALL 005
OUTFALL 006
OUTFALL 007
OUTFALL 008
A-17
BACKGROUND WATER
GEORGIA PACIFIC CORPORATION
"A", "B" POSSIBLE (SUBMERGED) DISCHARGE

Figure IV-8. Whatcom Creek Waterway Area

A-17 Georgia Pacific Corporation [2-081]--The Corporation reported eight waste discharges totalling 200,000 m^3/day (52.7 mgd). The flow distribution was as follows:

Outfall	Discharge (m^3/day)	Discharge (mgd)
001	6,800	1.8
002	4,900	1.3
003	13,000	3.5
004	49,000	13.0
005	80,000	21.0
006	20,000	5.3
007	19,000	5.0
008	6,100	1.6

Outfall 002 reportedly discharges process and sanitary wastes and the other outfalls discharge process wastes and cooling water.

In both April and July the discharges from Outfalls 004, 005 and 006 created a large white plume with surface foam that spread up and down Whatcom Creek Waterway in an irregular shape [Fig. IV-8]. The average plume width was 10 m (33 ft) and the overall length was 200 m (660 ft). The discharge from Outfall 003 was similar in appearance to the three main outfalls but much smaller in volume. In April no discharges were recorded for Outfalls 001, 002, 007 and 008. However, the characteristics of a submerged discharge were recorded at point "A."

In July Outfalls 002 and 008 were active. A white foam-like substance floating on the water surface indicated the possible presence of discharges at points "A" and "B." No outfalls were reported at these two locations.

A-18 Unknown Discharge--In April a large red-brown plume was observed in the lower reach of Whatcom Creek Waterway. The plume appeared to contain a significant amount of suspended solids [Fig. IV-8].

ANACORTES (AREA B)

Description of Area

This study area included the waters at the north end of Fidalgo Island in the vicinity of Anacortes [Fig. IV-1]. Padilla Bay on the east side of the study area is the southern portion of the Bellingham oceanographic unit. The Bay is separated from the San Juan Islands Channels to the west by Fidalgo and Guemes Islands. Guemes Channel between the two Islands connects Padilla Bay to the deepwater Rosario Strait to the west. Water quality in Padilla Bay is influenced by freshwater inflow to Bellingham and Samish Bays to the north and the tidal interchange through Guemes Channel. There are no significant freshwater inflows in the study area.

The waters of primary interest in the study area are the Guemes Channel, Fidalgo Bay, and the southwestern portion of Padilla Bay [Fig. IV-9]. Guemes Channel is a narrow waterway with depths in excess of 23 m (75 ft) at mid-channel. In contrast, Fidalgo Bay is shallow with water depths less than 2 m (6 ft). The western shore of Padilla Bay is also shallow.

Anacortes with a population of about 8,000 is the economic center of the area. Known waste discharges in Anacortes are primarily from food processing and pulp and paper industries. Two oil refineries and a chemical plant are located east of Anacortes between Fidalgo and Padilla Bays.

General Observations

The open waters of Padilla Bay and Guemes Channel were gray-green. Water in the Anacortes Marina was dark green. A moderate amount of

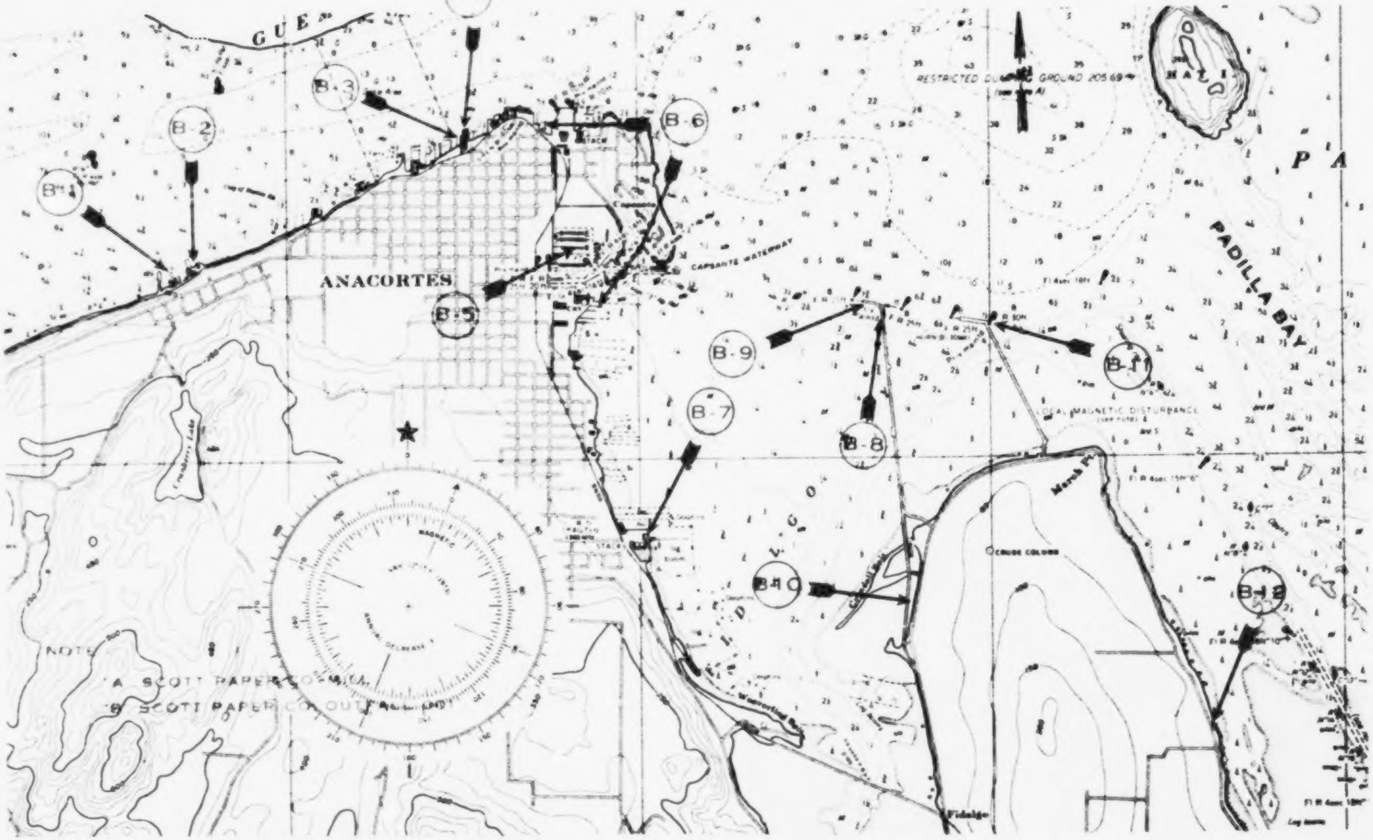

B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
B-9
B-10
B-11
B-12
ANACORTES
PADILLA BAY
GUE
P A
RESTRICTED DUMPING GROUND 205.69
CAPSANTE WATERWAY
LOCAL MAGNETIC DISTURBANCE
NOTE
A SCOTT PAPER CO. MILL
B SCOTT PAPER CO. OUTFALL
MAGNETIC
Fidalgo

Figure IV–9. Anacortes Area

turbidity was present in shallow waters of Fidalgo Bay along the southern Anacortes shoreline.

Specific Observations

B-1 Unknown Discharge--In April an outfall was discharging a large volume of a white colored substance at this location [Fig. IV-9] producing a plume that drifted westward for 1,830 m (6,000 ft) before completely dispersing. A relative isodensity sketch of the plume is shown in Figure IV-10. The area labeled "1" was the most dense and "8" represents background water. The outfall was not active in July.

B-2 Northwest Fur Breeders [3-184]--This facility reportedly has a batch discharge of 30 m^3/day (8,000 gpd). A discharge was not observed during either mission.

B-3 Whitney-Fidalgo [3-184]--Outfall 003 was discharging with considerable force in July creating many irregular shaped gray-green plumes [Fig. IV-9]. The general area appeared to contain a significant amount of oil. The plumes were dispersing in a northeasterly direction throughout the waterfront area during a flood tide condition. Outfalls 001 and 002 were also discharging in July but did not contribute significantly to the plume created by the discharge from Outfall 003. The three outfalls reportedly discharge a total of 650 m^3/day (0.17 mgd) of process and sanitary wastes and boiler blowdown.

B-4 Fisherman's Packing Corporation [2-289]--This facility reportedly has two outfalls that discharge under the pier. The effects of these discharges could not be determined because of the presence of the plumes originating from the Whitney-Fidalgo Facility.

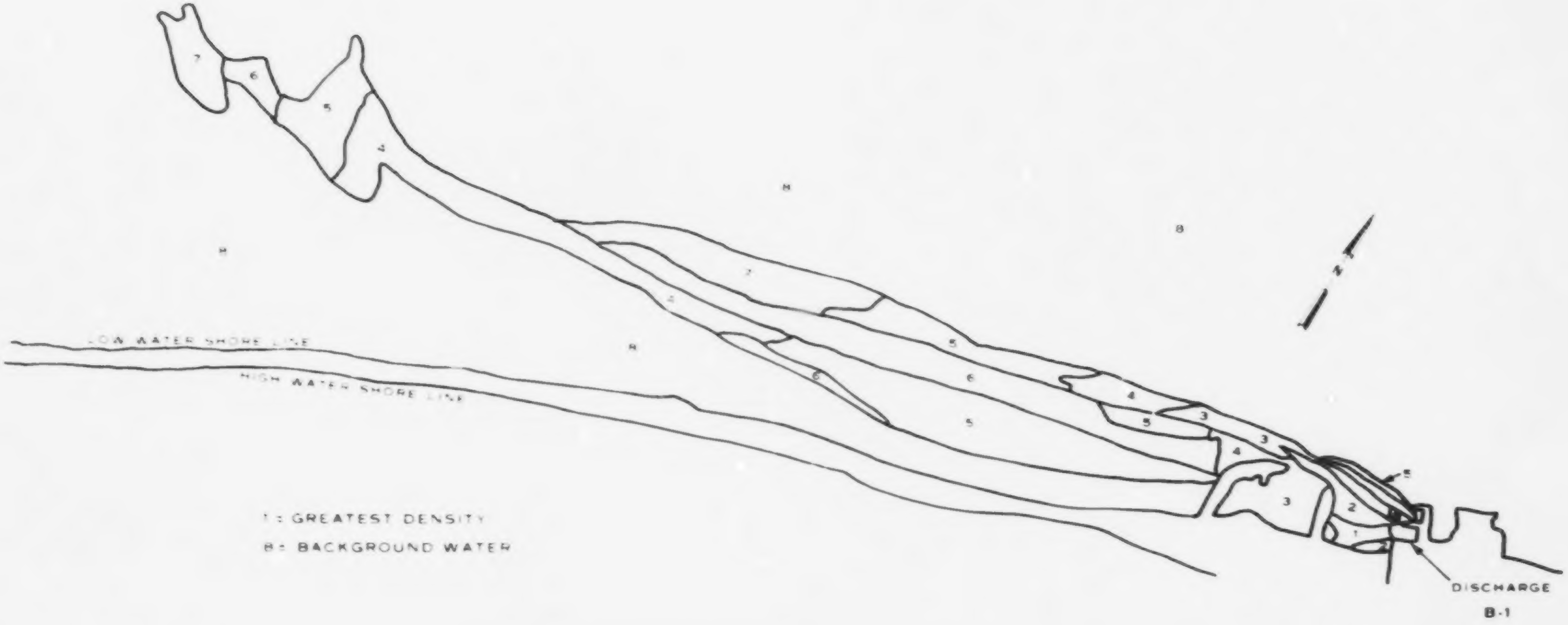

N
B
LOW WATER SHORE LINE
HIGH WATER SHORE LINE
1 = GREATEST DENSITY
B = BACKGROUND WATER
DISCHARGE
B-1
1
2
3
4
5
6
7

Figure IV-10. Isoconcentration Sketch of Industrial Discharge

B-5 Anacortes Marina--Extensive oil slicks were recorded inside the boat marina in both April and July. In July the slicks contained about 106 liters (28 gal.) of oil.

B-6 Scott Paper Company [3-049]--This mill is south of the marina [arrow "A," Fig. IV-9]. In 1971 the company reported the discharge of 24,400 m^3/day (6.42 mgd) of mill effluent to Guemes Channel through Outfall 001, located under the dock and indicated by arrow "B." This outfall was to be replaced by a submerged diffuser 210 m (680 ft) off the dock face. The water in the shore indentation adjacent to Outfall 001 contained a high concentration of suspended solids. No discharge was observed nor was there any indication of the submerged diffuser. Water discoloration around Outfalls 002, 003, and 004 is shown in Figure IV-11.

B-7 Publishers Forest Products [2-202]--This facility reportedly discharges 550 m^3/day (0.145 mgd) of process wastewater and boiler blowdown to Fidalgo Bay through multiple floor drains in the mill building [Fig. IV-12]. A discharge plume was not detected but numerous small oil slicks were present in the immediate area.

B-8 Texaco Corporation Refinery [3-053]--The refinery reported a discharge of 11,000 m^3/day (2.88 mgd) through Outfall 001 located at the bend in their pier [Fig. IV-13]. A visible plume was not recorded in the immediate vicinity of the reported outfall location. In April a small red-gray plume 2 m (6 ft) wide and 12 m (40 ft) long was visible near the end of the pier. This indicated the possibility of a leak or unreported outfall although tidal action could have caused effluent from Outfall 001 to surface at this location.

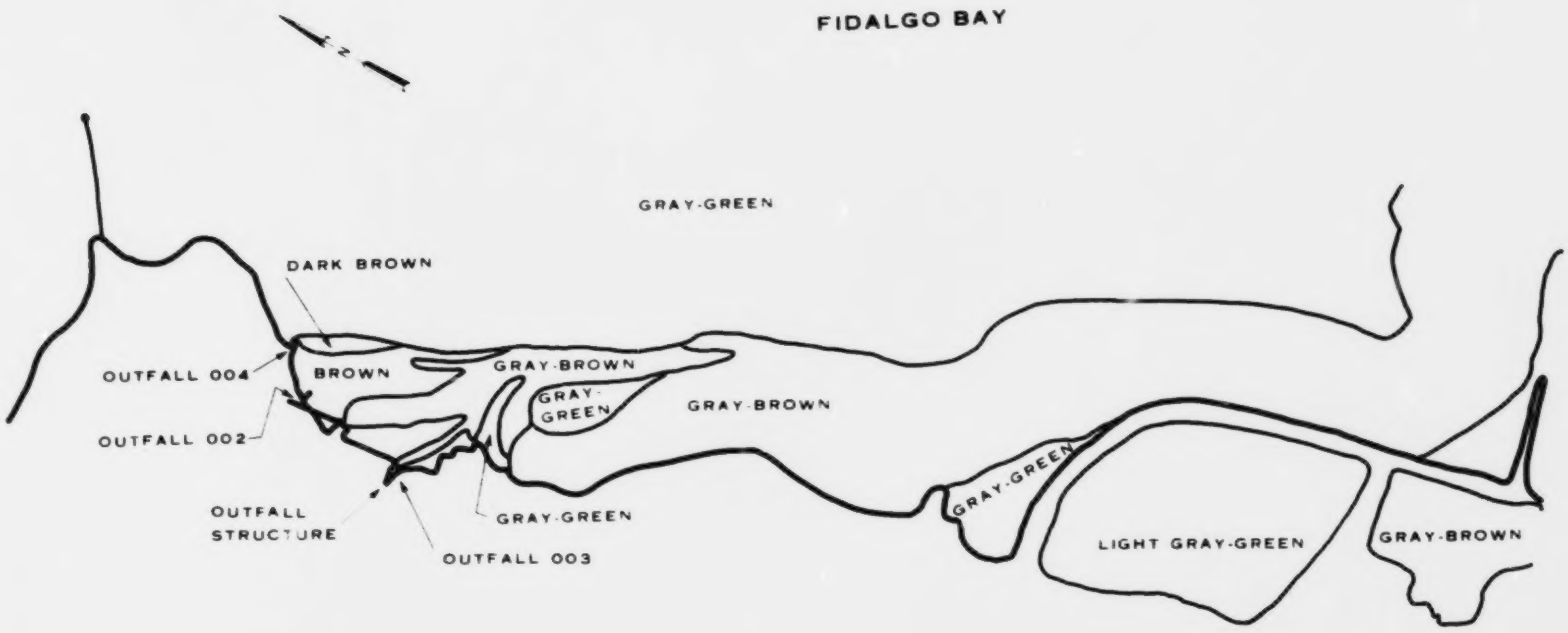

FIDALGO BAY
N
GRAY-GREEN
DARK BROWN
OUTFALL 004
BROWN
GRAY-BROWN
GRAY-GREEN
GRAY-BROWN
OUTFALL 002
OUTFALL STRUCTURE
GRAY-GREEN
OUTFALL 003
GRAY-GREEN
LIGHT GRAY-GREEN
GRAY-BROWN

Figure IV-11. Scott Paper Company

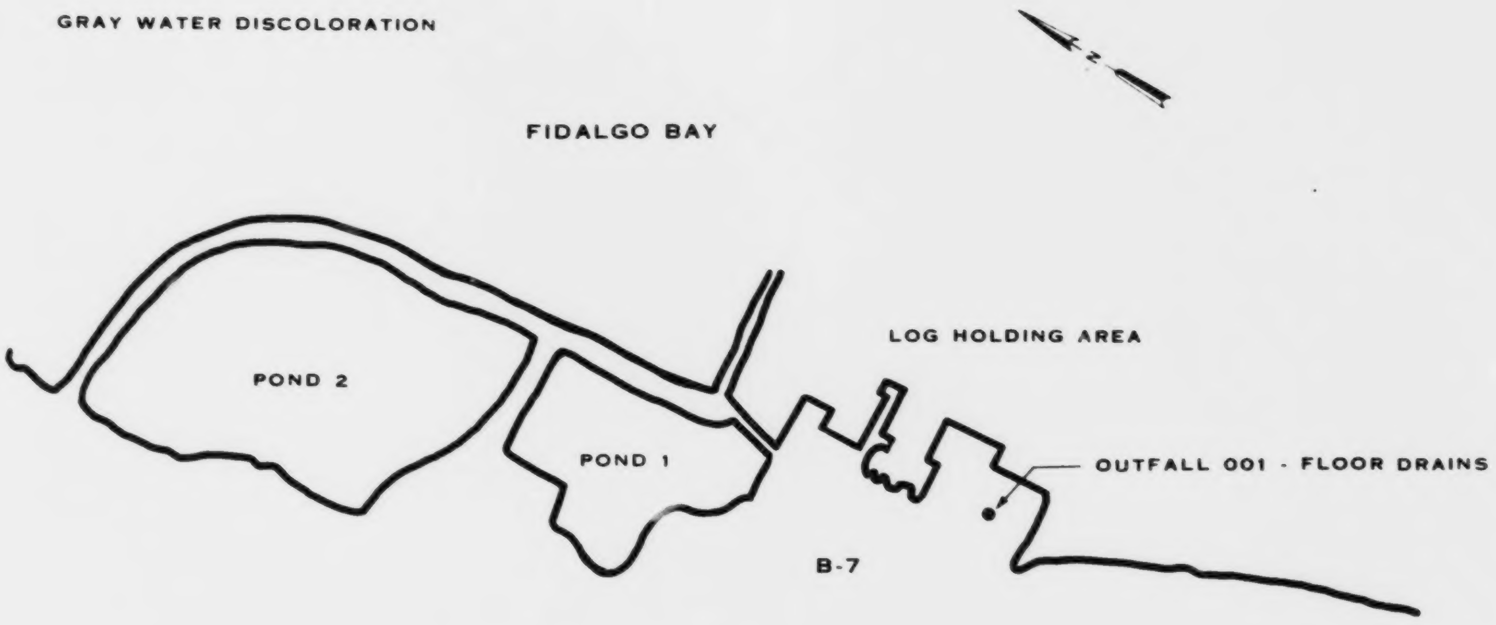

GRAY WATER DISCOLORATION
N
FIDALGO BAY
LOG HOLDING AREA
POND 2
POND 1
OUTFALL 001 - FLOOR DRAINS
B-7

Figure IV-12. Publishers Forest Products

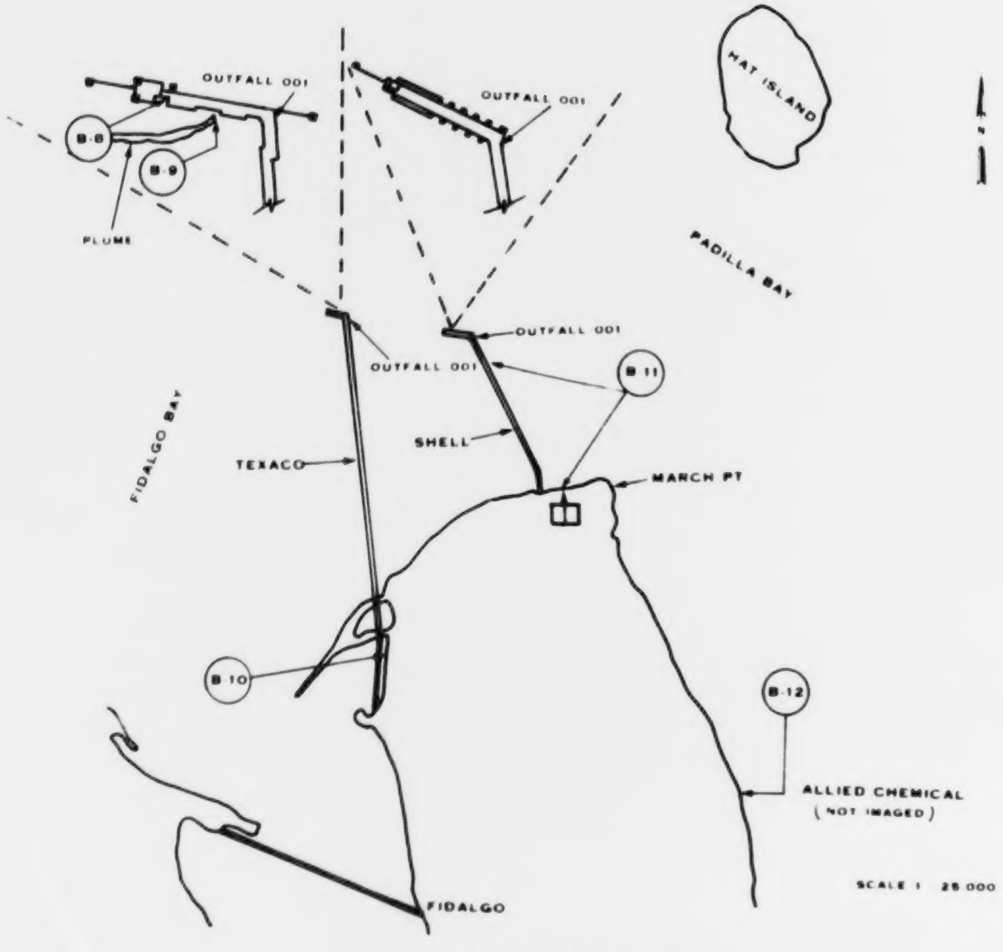

OUTFALL 001
B-8
B-9
PLUME
OUTFALL 001
HAT ISLAND
PADILLA BAY
OUTFALL 001
OUTFALL 001
B-11
FIDALGO BAY
TEXACO
SHELL
MARCH PT
B-10
B-12
ALLIED CHEMICAL
(NOT IMAGED)
SCALE 1 : 25 000
FIDALGO

Figure IV-13. Texaco and Shell Refineries

B-9 Texaco (Continued)--In July a red-gray plume 7 m (23 ft) wide and 195 m (640 ft) long was recorded as shown in Figure IV-13. Again, this may have been an unreported discharge or the effluent from Outfall 001 deflected by tidal action as discussed under B-8 above.

B-10 Texaco (Continued)--A culvert extends from the east side of the road to the beach at this location [Fig. IV-13]. No discharge was detected.

B-11 Shell Oil Company [2-034]--Shell reportedly discharges 16,700 m^3/day (4.4 mgd) of cooling and process wastewater through a single submerged outfall at the end of their pier [Fig. IV-13]. No visible plume was observed. A pipe that appeared to be an overflow system extended from the holding pond to the beach. No discharge was observed.

B-12 Allied Chemical Corporation [2-132]--This company reportedly discharges 300 m^3/day (0.08 mgd) of cooling and process wastewater. The plant location was not imaged by either flight.

PORT TOWNSEND (AREA C)

Description of Area

With a population of about 6,000, the city of Port Townsend is situated at the northeastern end of the Quimper Peninsula on the western shore of Admiralty Inlet [Fig. IV-1]. Port Townsend Bay extends southward from the city and is separated from the Inlet by Marrowstone and India Islands. Admiralty Inlet is the main connection between the Puget Sound system and the Strait of Juan de Fuca. Saline bottom waters flowing inland from the Strait and less saline surface waters flowing seaward from the Sound are mixed in the Inlet by strong tidal currents. Water quality in Port Townsend Bay is controlled by tidal interchange with the Inlet waters and is thus subject to seasonal changes as the freshwater inflow to the Puget Sound system varies. Water depths in Port Townsend Bay average 18 m (60 ft). Depths of 9 m (30 ft) occur near shore.

General Observations

Port Townsend Bay was gray-green, comparable to open waters of the Puget Sound area. Water within the Port Townsend marina was dark green. Bottom features near shore were clearly visible.

Specific Observations

C-1 Unknown Outfall--A small yellow-green plume about 3 x 8 m (10 x 26 ft) originating about 26 m (85 ft) southeast from the end of the pier indicated the presence of a submerged discharge [Fig. IV-14].

C-2 Oil Slick--An oil slick containing about 19 liters (5 gal.) of oil was observed in the marina in July. The apparent source of the oil was a dredge operating in the marina.

C-3 Crown Zellerbach Corporation [2-055]--This kraft pulp and paper mill is located on Glen Cove west of Port Townsend [Fig. IV-14]. A yellowish-orange discoloration was recorded in the adjacent waters. In April this discoloration was general but in July a definite plume extending about 550 m (1,800 ft) up and down the shoreline was present. No specific discharges were identified.

The mill reported four wastewater discharges [Fig. IV-15]. Outfall 001 is a minor discharge from the bag conversion plant. Outfall 002 discharges an average of 1,800 m^3/day (0.47 mgd) of cooling water under the dock. Outfall 003 discharges about 22,000 m^3/day (5.9 mgd) of barometric condenser water from the black water evaporator through a pipe terminating between high and low tide elevations; this pipe was submerged at flight times. The main process wastewater stream, with a flow rate of 34,000 m^3/day (8.9 mgd), receives primary treatment and then is discharged through a 550 m (1,800 ft) long submerged outfall (004). The discharge depth is about 14 m (46 ft).

At point "A" [Fig. IV-15], there was evidence that overflow from the pond enters Glen Cove but no flow was observed.

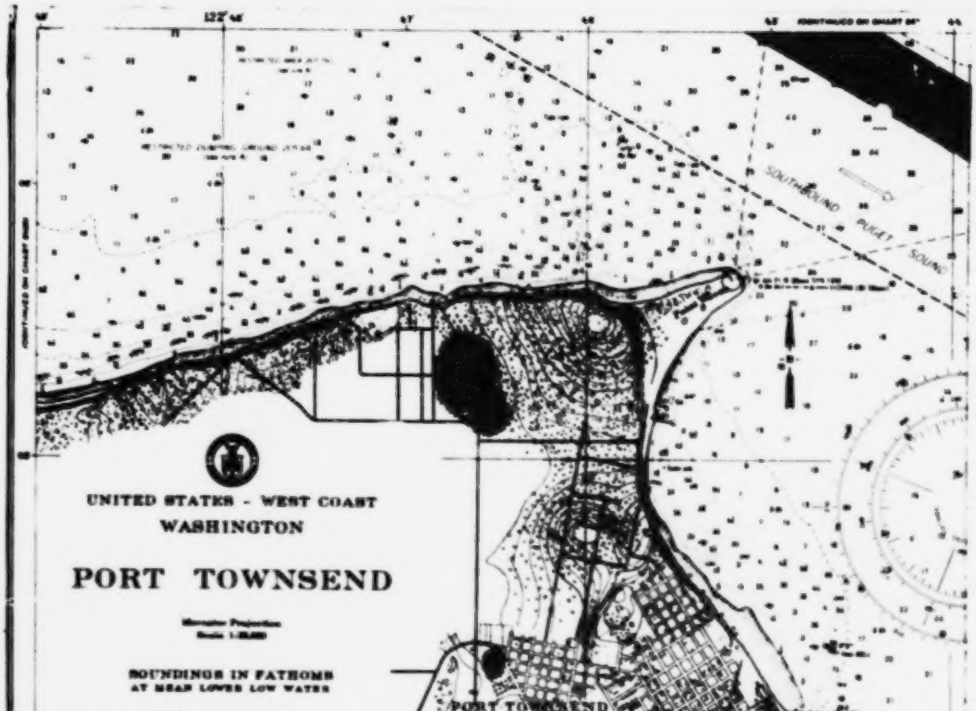

122° 48'
SOUTHBOUND PUGET SOUND
UNITED STATES - WEST COAST
WASHINGTON
PORT TOWNSEND
SOUNDINGS IN FATHOMS
AT MEAN LOWER LOW WATER
PORT TOWNSEND
C-1
C-2
PORT TOWNSEND
C-3

Figure IV–14. Port Townsend Area

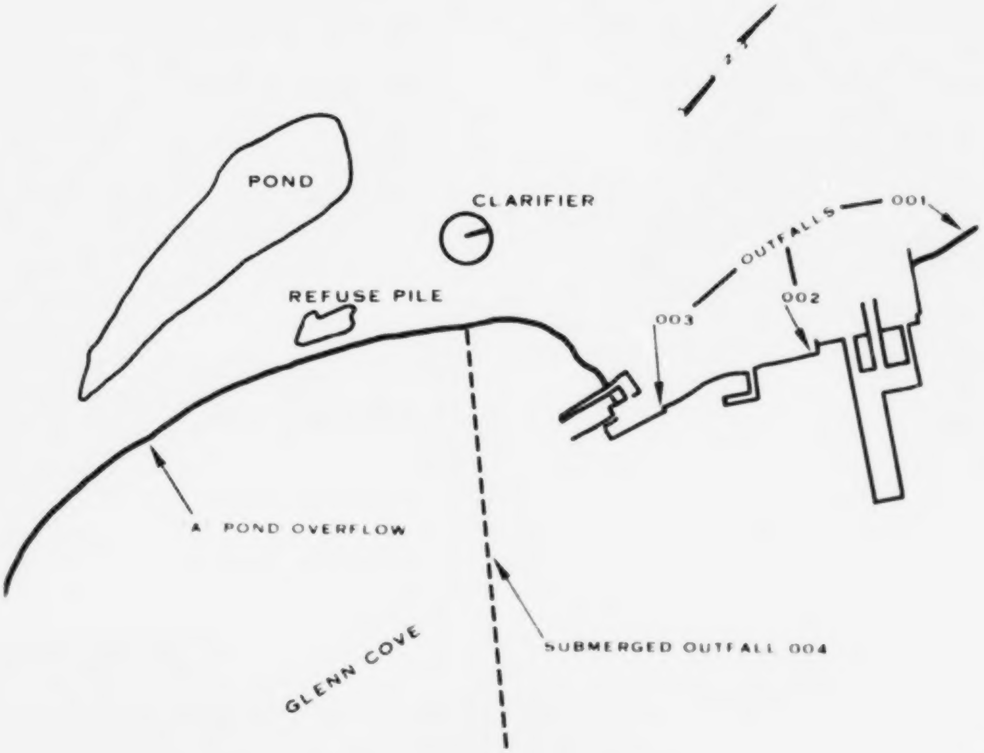

N
POND
CLARIFIER
REFUSE PILE
OUTFALLS
001
002
003
A POND OVERFLOW
SUBMERGED OUTFALL 004
GLENN COVE

Figure IV-15. Crown Zellerbach Corporation

EVERETT (AREA D)

Description of Area

Everett, with a population of about 55,000, is located north of the Seattle metropolitan area [Fig. IV-1]. The city fronts on Port Gardner, the northeast arm of Possession Sound which is an arm of Puget Sound. The Snohomish River enters Possession Sound at Everett.

The presence of the Snohomish River exerts a major influence on water quality in the Everett vicinity. Average river flow is 270 m^3/sec (9,500 cfs). This freshwater discharge affects the salinity of surface waters and circulation patterns, especially during periods of high runoff.

The river has created a large shallow water area at its mouth with depths less than 1 to 2 m (3 to 6 ft) [Fig. IV-16]. In sharp contrast, adjacent waters of Possession Sound are as much as 90 to 120 m (300 to 400 ft) deep. Everett Harbor, extending along the Everett waterfront from Port Gardner to the mouth of the Snohomish River, has water depths ranging from 2 to 5 m (6 to 16 ft). The Harbor provides a dredged shallow-draft entrance to the north waterfront area and the Snohomish River.

The principal waste sources of interest in this area are three pulp and paper mills and two wood products facilities.

General Observations

The waters of the Snohomish River and Union and Steamboat Sloughs in areas not discolored by wastewater discharges were dark green. Port

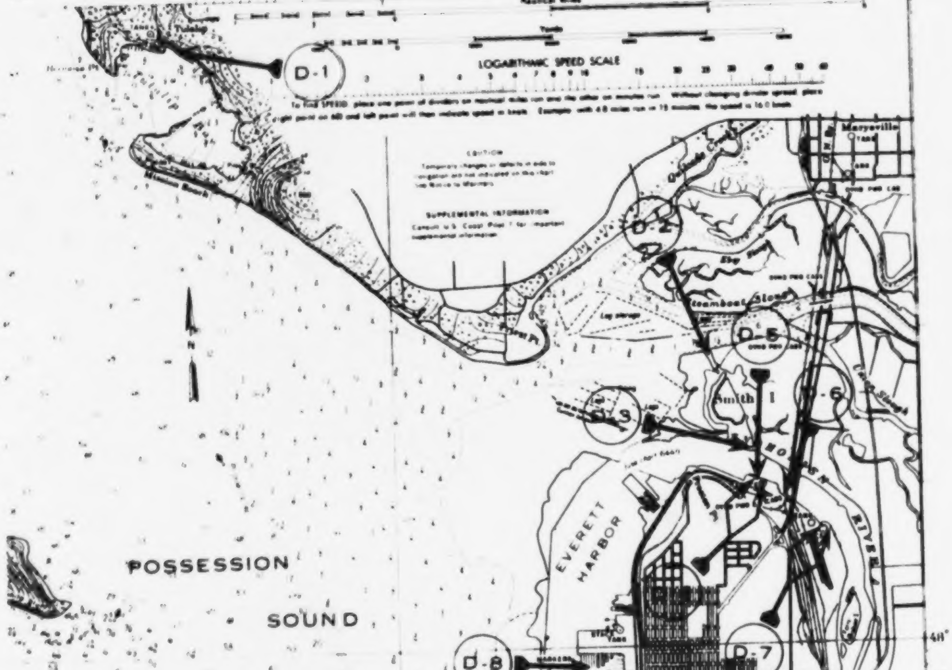

Nautical Miles
LOGARITHMIC SPEED SCALE
D-1
Marysville
D-2
Steamboat Slough
D-5
Smith I
D-6
D-3
EVERETT HARBOR
SNOHOMISH RIVER
POSSESSION
SOUND
D-7
D-8
D-9
EVERETT
D-15
THRU
D-22
SEE FIGURE IV-23
D-24
EVERETT HARBOR AND SNOHOMISH RIVER
MUKILTEO
D-23
LOWELL

Figure IV—16. Everett Area

Gardner was also dark green. Bottom features were not visible. Extensive log storage areas occupied most of the shoreline in Everett Harbor.

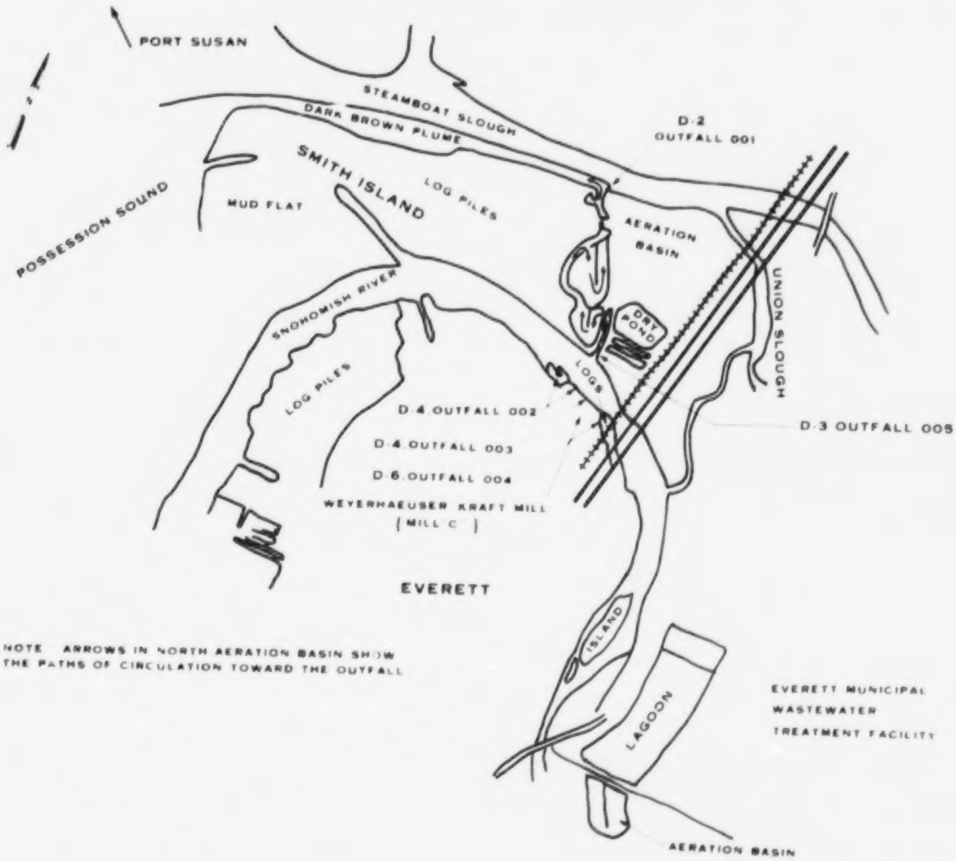
Specific Observations

The Weyerhaeuser Company operates three facilities at Everett. A sulfite pulp mill (Mill A) is on Port Gardner in Everett. A lumber facility (Mill B) and a kraft pulp mill (Mill C) near the mouth of the Snohomish River have adjacent outfalls.

D-1 Tulalip River--The river discharges to the shallow (less than 2 m) Tulalip Bay [Fig. IV-15]. Suspended solids in the river flow created a large gray plume in the bay that extended southward along the eastern shore for about 610 m (2,100 ft).

D-2 Weyerhaeuser Company, Everett Kraft Mill (Mill C) [3-072]--Weyerhauser's Everett Kraft Mill is on the south bank of the Snohomish River at arrow D-4, Figure IV-16. The main process wastewater stream, with a flow rate of 87,000 m^3/day (23 mgd), is discharged to an aeration pond system on Smith Island across the river [Fig. IV-17 and IV-18]. Pond effluent is discharged through Outfall 001 to Steamboat Slough in two batches per day during ebb tide phases. This effluent created a long dark brown plume in the Slough that moved downstream into Possession Sound before dissipating. There was no indication during either flight that the effluent was being washed into Port Susan.

D-3 Weyerhaeuser Kraft Mill (Continued)--No discharge was observed from Outfall 005 [Fig. IV-17 and IV-19]. This tide gate is a possible overflow structure for the aeration system on Smith Island.


PORT SUSAN
STEAMBOAT SLOUGH
DARK BROWN PLUME
SMITH ISLAND
LOG PILES
MUD FLAT
POSSESSION SOUND
D-2
OUTFALL 001
AERATION
BASIN
DRY
POND
UNION SLOUGH
SNOHOMISH RIVER
LOG PILES
LOGS
D-4 OUTFALL 002
D-4 OUTFALL 003
D-6 OUTFALL 004
D-3 OUTFALL 005
WEYERHAEUSER KRAFT MILL
(MILL C)
EVERETT
ISLAND
LAGOON
EVERETT MUNICIPAL
WASTEWATER
TREATMENT FACILITY
AERATION BASIN

NOTE ARROWS IN NORTH AERATION BASIN SHOW THE PATHS OF CIRCULATION TOWARD THE OUTFALL

Figure IV-17. Weyerhaeuser Everett Kraft Mill

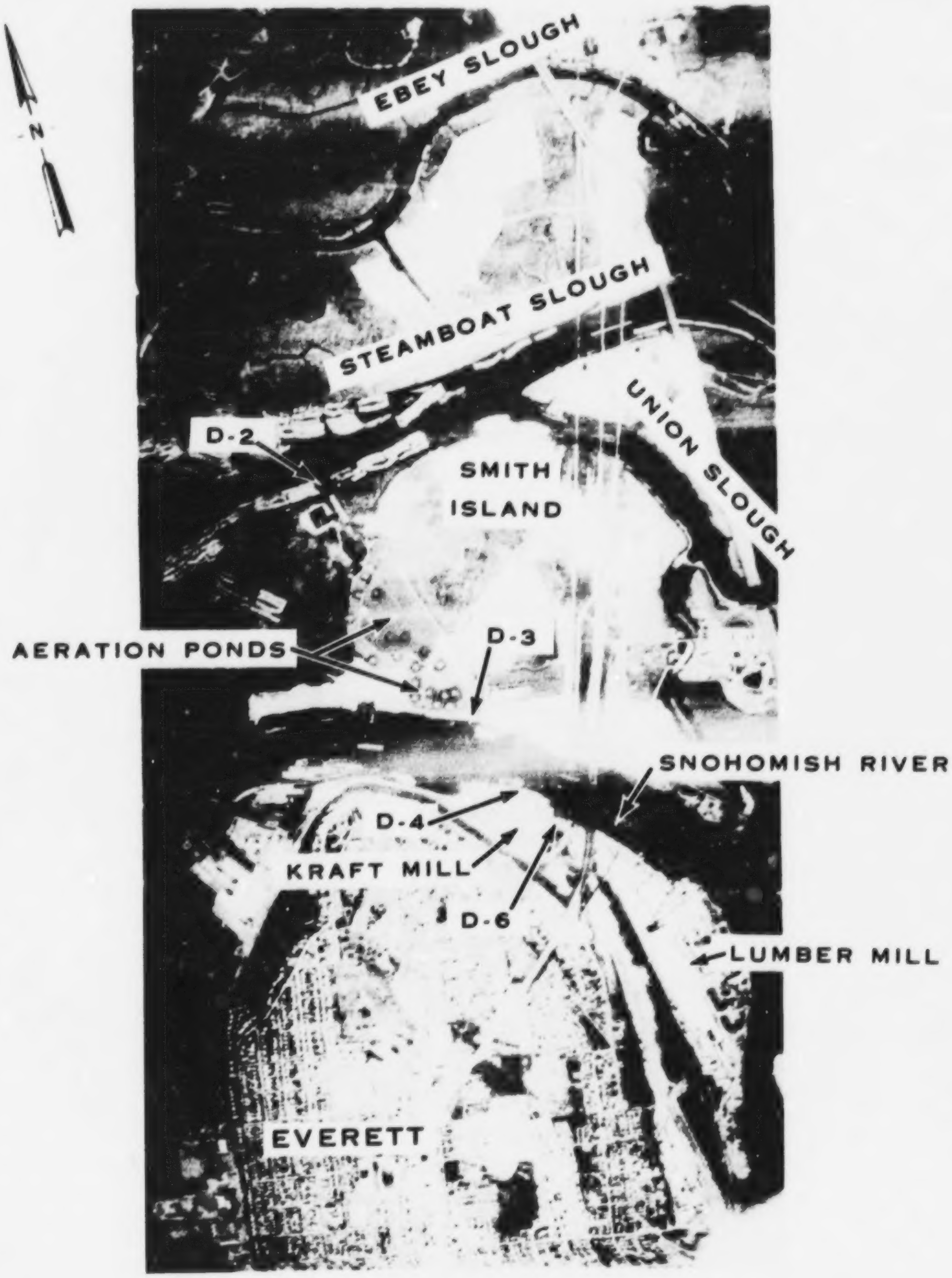

N
EBEY SLOUGH
STEAMBOAT SLOUGH
UNION SLOUGH
D-2
SMITH ISLAND
AERATION PONDS
D-3
SNOHOMISH RIVER
D-4
KRAFT MILL
D-6
LUMBER MILL
EVERETT

Figure IV–18. Weyerhaeuser Facilities

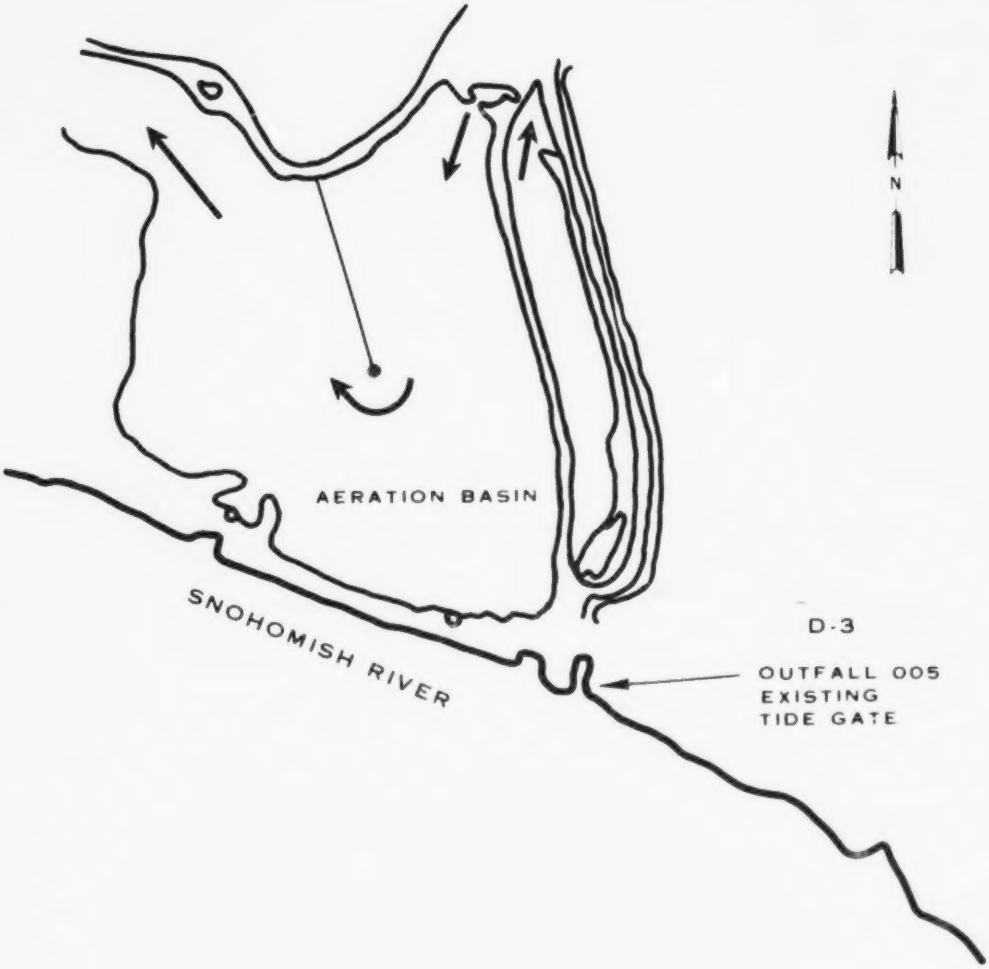

N
AERATION BASIN
SNOHOMISH RIVER
D-3
OUTFALL 005
EXISTING
TIDE GATE

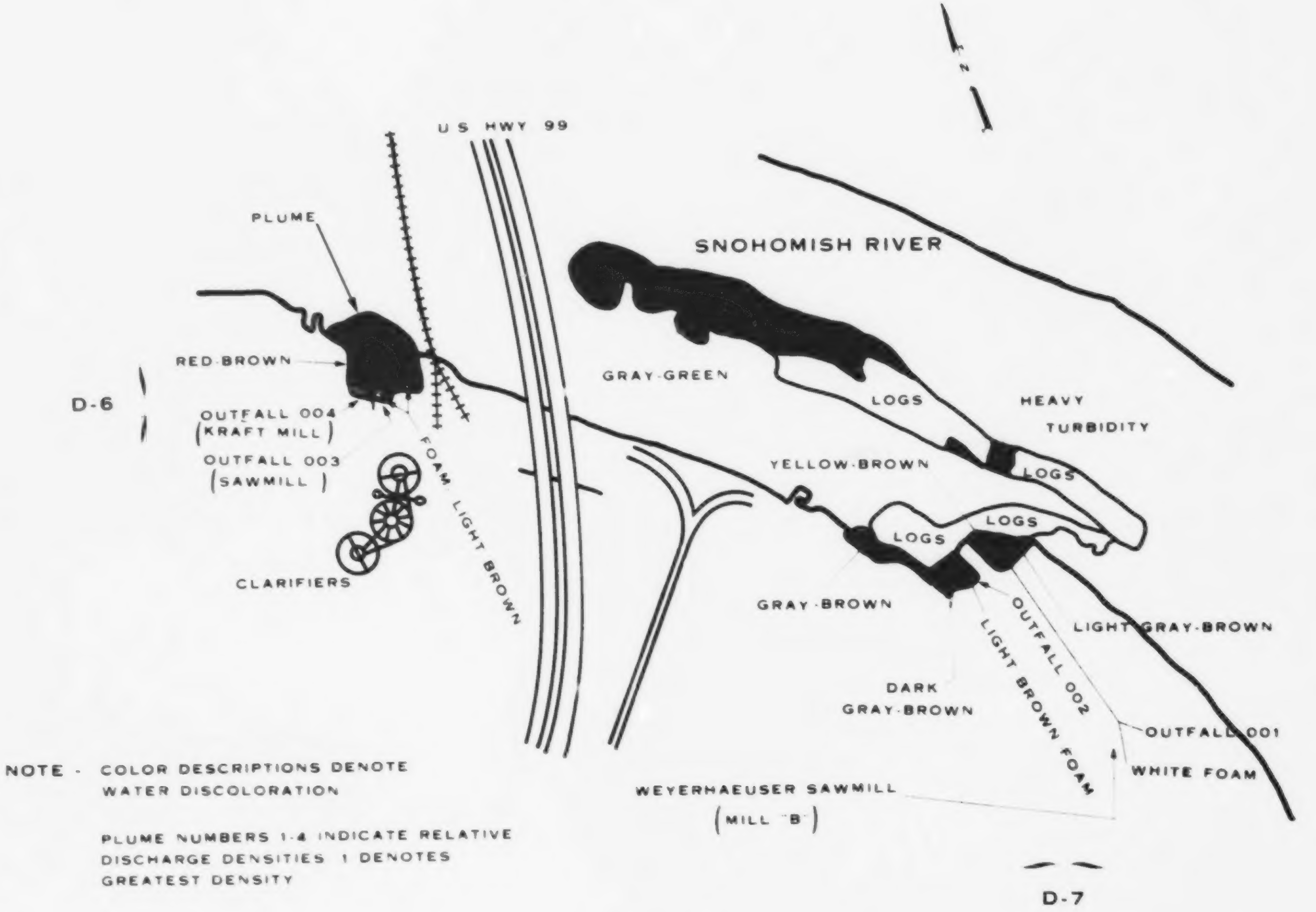
Figure IV-19. Weyerhaeuser Aeration Basin

D-4 Weyerhaeuser Kraft Mill (Continued)--Three outfalls from the mill discharge to the Snohomish River at this location. Outfall 002 [Fig. IV-17], with a flow rate of 19,000 m^3/day (5 mgd) discharges under a dock. No trace of the discharge was observed in the vicinity of the outfall. However, a small area of light yellow-brown turbidity was observed to the west of the outfall during a high tide condition.

The presence of steam or smoke and large log rafts prevented observation of the discharge from Outfall 003 which has a reported flow rate of 6,000 m^3/day (1.6 mgd). Outfall 004 is discussed under D-6 below.

D-5 Oil Slick--An oil slick was recorded in the Snohomish River immediately downstream from the railroad bridge. It contained about 68 liters (18 gal.) of refined oil. The source appeared to be two boats that were moving logs.

D-6 Weyerhaeuser Company Sawmill Complex (Mill B) [3-682]--Weyerhauser operates a large lumber mill on the Snohomish River upstream of their kraft mill at location D-7 [Fig. IV-16, IV-18, IV-20]. Waste discharges from both the kraft mill (Outfall 004) and the sawmill (Outfall 003) are located at D-6. A red-brown plume was present in the Snohomish River with the relative levels of discoloration shown in Figure IV-20 by the numbered areas with No. 1 the greatest. The color of the waste plume was identical to wastewater in the clarifiers onshore. This would indicate that the plume was from Outfall 003 (sawmill) with a reported flow rate of about 3,800 m^3/day (1 mgd). The discoloration in the receiving water prevented detection of the discharge from Outfall 004 (kraft mill) with a reported flow rate of 5,700 m^3/day (1.5 mgd).


N
U S HWY 99
SNOHOMISH RIVER
PLUME
RED-BROWN
D-6
OUTFALL 004
(KRAFT MILL)
OUTFALL 003
(SAWMILL)
CLARIFIERS
FOAM LIGHT BROWN
GRAY-GREEN
LOGS
HEAVY
TURBIDITY
YELLOW-BROWN
LOGS
LOGS
LOGS
GRAY-BROWN
OUTFALL 002
LIGHT BROWN FOAM
LIGHT GRAY-BROWN
DARK
GRAY-BROWN
OUTFALL 001
WHITE FOAM
WEYERHAEUSER SAWMILL
(MILL "B")
D-7

NOTE - COLOR DESCRIPTIONS DENOTE WATER DISCOLORATION

PLUME NUMBERS 1-4 INDICATE RELATIVE DISCHARGE DENSITIES 1 DENOTES GREATEST DENSITY

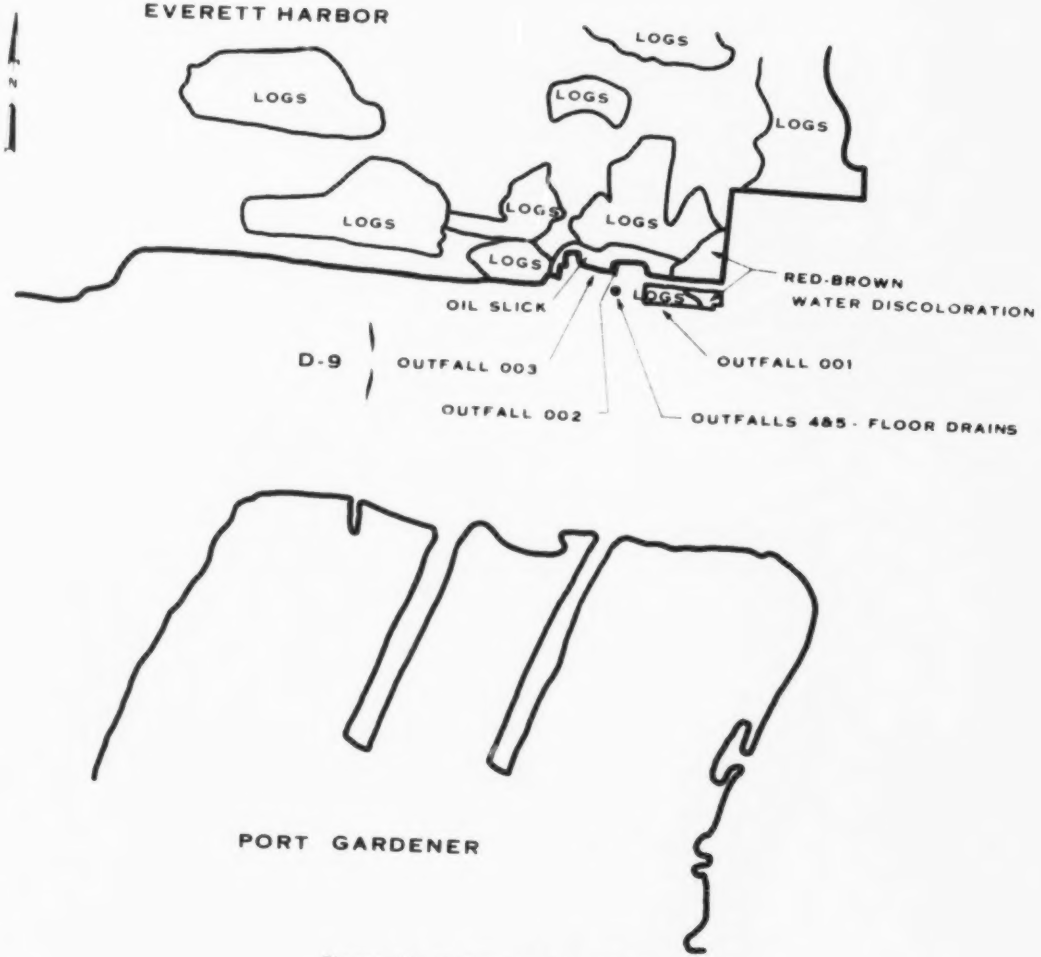
Figure IV-20. Weyerhaeuser Sawmill Complex

D-7 Weyerhaeuser Sawmill (Continued)--The discharge from Outfall 001 was clearly visible creating white and light brown foam and a yellow-brown plume. This effluent has a reported flow rate of 3,800 m^3/day (1 mgd). Outfall 002 reportedly batch discharges 2.8 m^3 (750 gal.) four times daily. The river in the immediate vicinity of this outfall was covered with a light gray-brown foam and the water along shore was gray-brown.

D-8 Oil Slick--An oil slick containing about 77 liters (20 gal.) of oil (possibly engine oil) was observed in the northern side of the small boat marina.

D-9 Everett Plywood Corporation [2-286]--In the immediate vicinity of this facility, Everett Harbor was discolored and several small oil slicks were present [Fig. IV-21 and IV-22]. The mill reportedly discharges about 1,100 m^3/day (0.3 mgd) of cooling water and process wastes from the manufacture of plywood through five outfalls to Everett Harbor. These outfalls are under the dock or submerged. Specific waste plumes were not observed.

D-10 Western Gear Corporation [3-224]--This facility manufactures construction machinery and equipment. Cooling and process wastewaters with an average flow of about 400 m^3/day (0.1 mgd) are discharged through five outfalls [Fig. IV-22 and IV-23]. At the time of flight, Outfalls 001 and 005 did not have any significant amount of flow. However, there was some discoloration in the harbor waters adjacent to these outfalls. These outfalls reportedly batch discharge small volumes frequently during the day. Wastewaters are from steam cleaning and sandblasting operations. No indication of a discharge from Outfall 002 was observed.



EVERETT HARBOR
N
LOGS
LOGS
LOGS
LOGS
LOGS
LOGS
LOGS
LOGS
LOGS
RED-BROWN
WATER DISCOLORATION
OIL SLICK
D-9
OUTFALL 003
OUTFALL 001
OUTFALL 002
OUTFALLS 4&5 - FLOOR DRAINS
PORT GARDENER

Figure IV–21 Everett Plywood Corporation

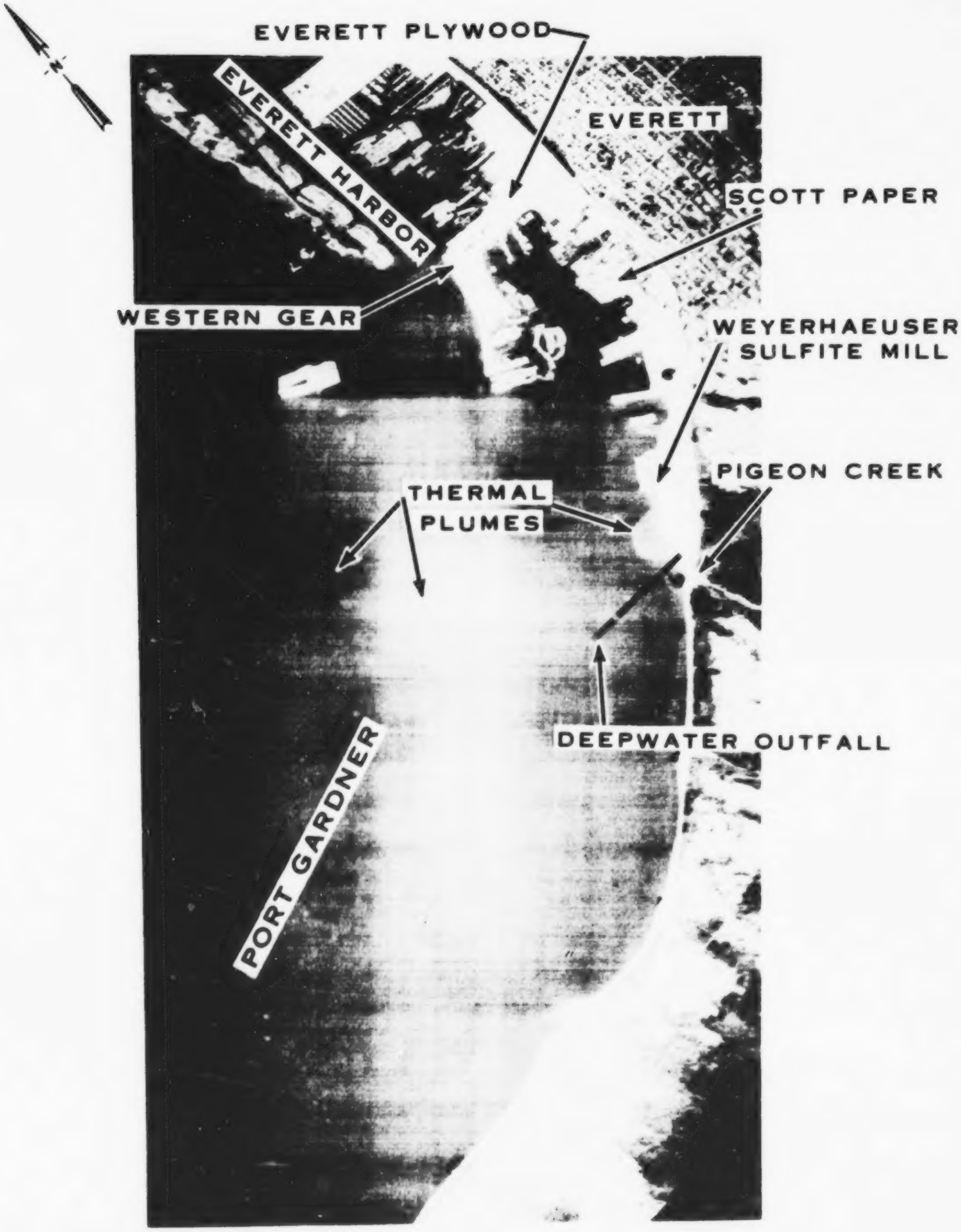

N
EVERETT PLYWOOD
EVERETT HARBOR
EVERETT
SCOTT PAPER
WESTERN GEAR
WEYERHAEUSER SULFITE MILL
PIGEON CREEK
THERMAL PLUMES
DEEPWATER OUTFALL
PORT GARDNER

Figure IV–22. Everett Waterfront

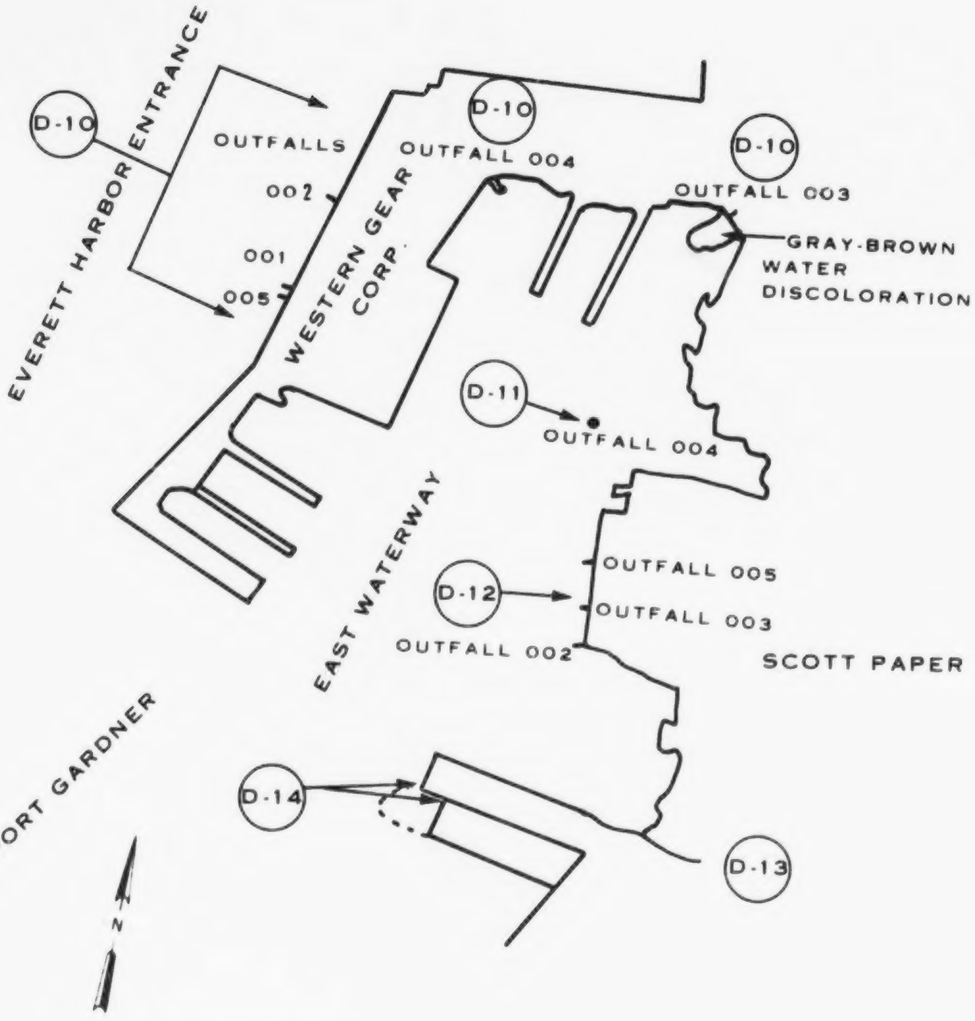

D-10
EVERETT HARBOR ENTRANCE
OUTFALLS
002
001
005
WESTERN GEAR CORP.
D-10
OUTFALL 004
D-10
OUTFALL 003
GRAY-BROWN WATER DISCOLORATION
D-11
OUTFALL 004
EAST WATERWAY
D-12
OUTFALL 005
OUTFALL 003
OUTFALL 002
SCOTT PAPER
PORT GARDNER
D-14
D-13
N

Figure IV-23. Northern Port Gardner Area

This discharge is reportedly (RAPP application) cooling water from an air compressor and air after-cooler. Outfall 003 was creating a gray-brown field of discoloration in Port Gardner that contained small amounts of oil. This discharge reportedly originates from steam cleaning activities and deburring machines. Small oil slicks were present in the vicinity of Outfall 004.

D-11 Scott Paper Company [2-014]--This pulp and paper mill has five wastewater discharges with a combined flow of about 227,000 m^3/day (60 mgd). Spent cooking liquors from the sulfite pulp process and blowpit washwaters averaging 42,000 m^3/day (11 mgd) are discharged through a deepwater outfall (001) jointly with wastewaters from the Weyerhaeuser Company. This outfall is discussed under D-21 below. Filtrate from the paper machine save-alls, averaging 19,000 m^3/day (5 mgd), is discharged to Port Gardner through a 180 m (600 ft) submerged outfall (004) [Fig. IV-23]. Average water depth at the discharge point is about 9 m (30 ft). A light yellow-gray plume was visible at the discharge point. The shape and relative density of the plume is sketched in Figure IV-24.

D-12 Scott Paper Company (Continued)--Outfalls 002, 003 and 005 are at this location. Outfall 002, the foam tank diffuser, is a submerged multi-port diffuser 12 m (40 ft) long positioned along the dock face and submerged in 8 m (25 ft) of water. Effluent, averaging 72,000 m^3/day (19 mgd), consists of pulp bleaching (chlorination washer) wastes and clarified process wastewaters that have passed through a foam separation tank. Discoloration of the receiving water adjacent to this outfall was minimal.

Outfall 003 is the main sewer diffuser reportedly discharging an average of 95,000 m^3/day (25 mgd) of excess white water, clarified process wastewaters, and some cooling water. The multiport diffuser extends 91 m (300 ft) along the dock face and is submerged 8 m (25 ft). This effluent was creating a yellow-brown plume and white surface foam as shown in Figure IV-24.

Outfall 005 reportedly discharges minor amounts of cooling water and boiler blowdown under the dock. The effects of this discharge could not be separated from the effects of Outfall 003.

D-13 Landfill Operation--A landfill operation was creating a moderate sized field of turbidity in this area [Fig. IV-23].

D-14 Dock Construction--In April a dock was under construction at this location [Fig. IV-23]. Surface disturbances and small plumes were visible. The construction was complete in July. The areas where discoloration of the receiving water was observed in April were covered and no discoloration was visible around the dock.

D-15 Weyerhaeuser Company, Everett Sulfite Mill (Mill A) [2-040]--Weyerhaeuser reported five wastewater discharges to tidal waters from this mill [Fig. IV-25]. A sixth discharge (005), from their water treatment plant, is to a small creek entering tidal waters south of the plant.

Outfall 006, a surface water drain is reportedly (RAPP application) located as shown in Figure IV-25. No discharge was observed. A dark gray-brown discoloration with the relative densities as shown was present in the area.

D-16 Weyerhaeuser Sulfite Mill (Continued)--A large light gray-brown field of discoloration and small white foam plume were present as

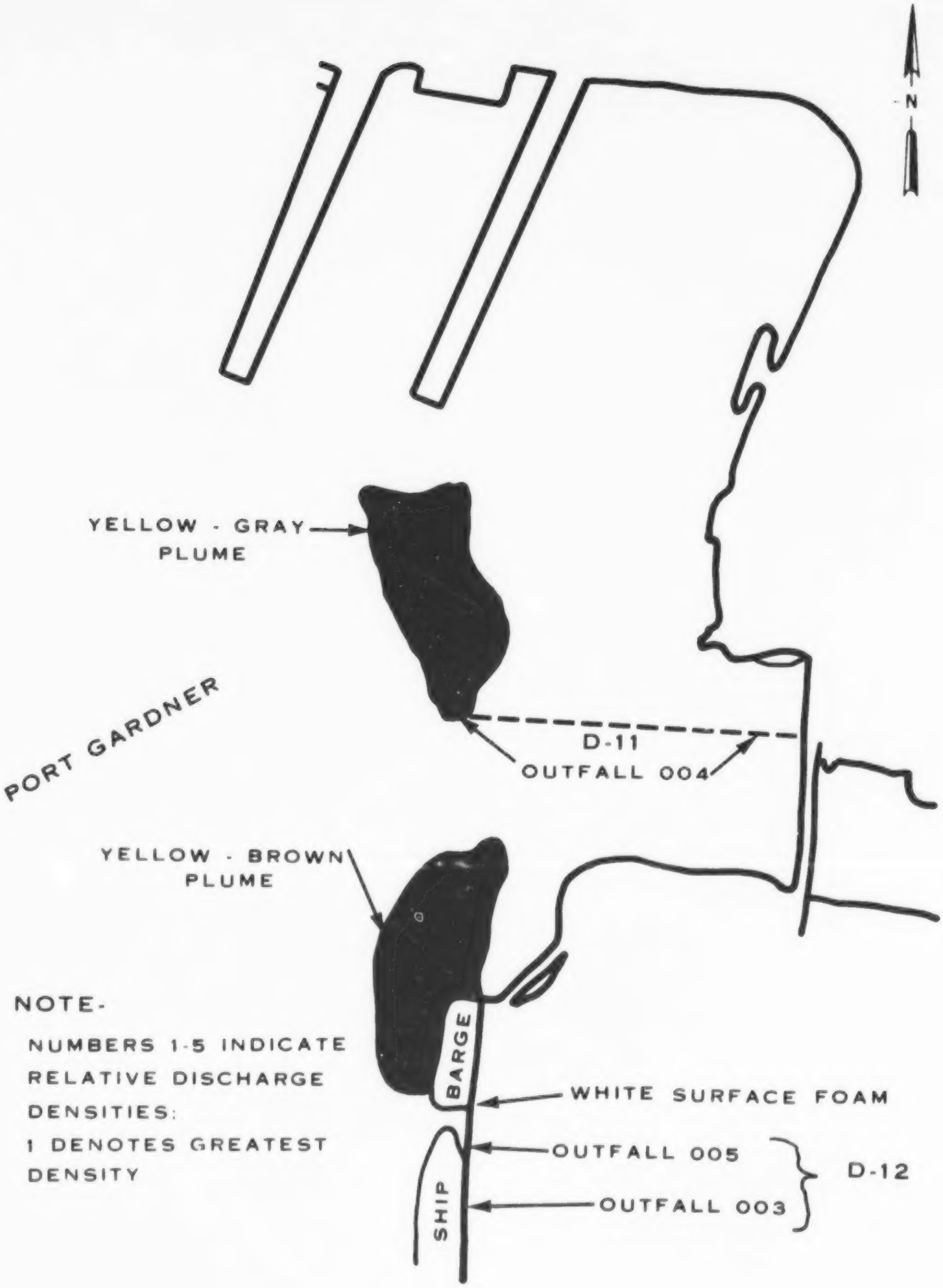
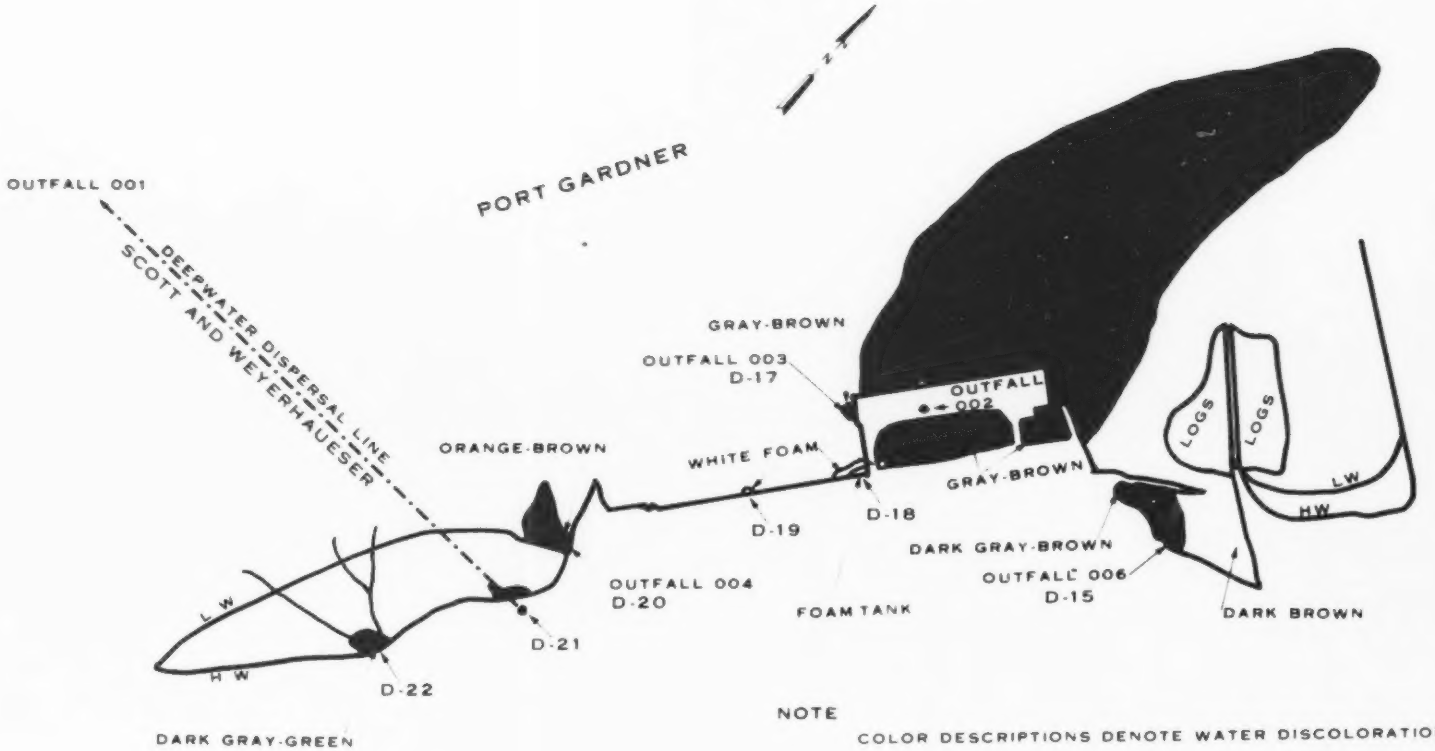

N
YELLOW - GRAY PLUME
PORT GARDNER
D-11
OUTFALL 004
YELLOW - BROWN PLUME
BARGE
WHITE SURFACE FOAM
OUTFALL 005
OUTFALL 003
D-12
SHIP
NOTE-
NUMBERS 1-5 INDICATE RELATIVE DISCHARGE DENSITIES:
1 DENOTES GREATEST DENSITY

Figure IV–24. Scott Paper Company


PORT GARDNER
N
OUTFALL 001
DEEPWATER DISPERSAL LINE
SCOTT AND WEYERHAEUSER
GRAY-BROWN
OUTFALL 003
D-17
OUTFALL
002
ORANGE-BROWN
WHITE FOAM
GRAY-BROWN
LOGS
LOGS
LW
HW
D-19
D-18
DARK GRAY-BROWN
OUTFALL 006
D-15
OUTFALL 004
D-20
FOAM TANK
DARK BROWN
L W
H W
D-21
D-22
DARK GRAY-GREEN

NOTE

COLOR DESCRIPTIONS DENOTE WATER DISCOLORATION

PLUME NUMBERS 1-3 INDICATE RELATIVE DISCHARGE DENSITIES WITHIN PLUME:
1 DENOTES GREATEST DENSITY

L W - LOW WATER LINE
H W - HIGH WATER LINE

Figure IV–25. Weyerhaeuser Everett Sulfite Mill

sketched in Figure IV-25. Outfall 002, the main process effluent discharged under the dock, was probably the source of these effects. This discharge reportedly consists of about 36,000 m^3/day (9.6 mgd) of tailing system and hydraulic barker effluent and wastewater from the powerhouse.

D-17 Weyerhaeuser Sulfite Mill (Continued)--Outfall 003 reportedly discharges an average of 26,000 m^3/day (6.8 mgd) of chlorinator effluent to Port Gardner through a submerged diffuser [Fig. IV-25]. The diffuser is 18 m (60 ft) long and submerged an average of 8 m (25 ft) at the southwest end of the dock. A gray-brown plume was observed at the end of the dock.

D-18 Weyerhaeuser Sulfite Mill (Continued)--Large amounts of white foam were being discharged at this shore location [Fig. IV-25]. A large plume was moving northeasterly along shore. A foam tank equipped with a bypass and overflow is located on the line to Outfall 003 at this position.

D-19 Weyerhaeuser Sulfite Mill (Continued)--White foam was present near shore at this location [Fig. IV-25].

D-20 Weyerhaeuser Sulfite Mill (Continued)--A surface drain (Outfall 004) from the mill area enters Port Gardner at this location [Fig. IV-25]. Flow averages 1,600 m^3/day (0.44 mgd). An orange-brown discoloration was present.

D-21 Weyerhaeuser Sulfite Mill (Continued)--Spent sulfite cooking liquor and caustic effluent averaging 38,000 m^3/day (10.1 mgd) are discharged to Port Gardner through a deepwater outfall (001) [Fig. IV-25]. This outfall also carries an average of 42,000 m^3/day (11 mgd) of process wastes from Scott Paper Company. The outfall extends 650 m (2,150 ft) offshore with the last 300 m (1,000 ft) of the outfall being a diffuser section. Water depths at the diffuser average 100 m (330 ft). A visible plume was not observed at the outfall location in either April or July. However, a high-altitude thermal map recorded in April indicated the possible surfacing of some of the wastewater further offshore in an area not photographed [Fig. IV-22].

D-22 Pigeon Creek--Pigeon Creek enters Port Gardner at this location through a culvert under the Great Northern Railroad. Filter backwash (Outfall 005) from the Weyerhaeuser water treatment plant is discharged to the creek 500 m (1,700 ft) upstream from its mouth. The effluent from the culvert was dark gray-green and created a small turbidity plume in Port Gardner.

D-23 Storm Drain--The bottom of the shallow near-shore waters was discolored at the mouth of this drain. Aquatic plant life was recorded in the area of discoloration. Topographic maps indicate a small tributary stream originates in a wooded suburban area at this location.

D-24 Oil Slicks--Several small oil slicks containing a total of 11 liters (3 gal.) of oil were recorded in the vicinity of this dock, a military fuel storage facility.

SEATTLE (AREA E)

Description of Area

The Seattle metropolitan area, with a population of about one million, is on the east shore of the main body of Puget Sound [Fig. IV-1]. Lake Washington, a 35 km (22 mi) long glaciated freshwater lake, parallels the Sound and bounds the metropolitan area on the east. The Lake Washington Ship Canal provides a connection between the Lake and the Sound. The canal was constructed by interconnecting several natural water bodies including Salmon Bay, Lake Union, Portage Bay and Union Bay. The Chittendon Locks near the west end of the canal separate the marine waters of Puget Sound from the fresh waters of the Lake Washington system. Freshwater outflow from the Lake through the canal controls salinity intrusions from the Sound.

Elliott Bay is a deepwater arm of Puget Sound extending into central Seattle. Water is as deep as 180 m (600 ft) in mid-bay and greater than 18 m (60 ft) near shore.

The Duwamish River enters Elliott Bay from the south. The river is tidal in the metropolitan area. The lower 11 km (7 mi) of the river has been dredged as the Duwamish Waterway. The area adjoining the waterway is one of the most heavily industralized in the state. The Duwamish River flow enters Elliott Bay through West Waterway on the west side of Harbor Island. During high runoff periods, flow also enters through East Waterway on the east side of the island.

Water quality in Elliott Bay and the Duwamish Waterway is influenced by both the Duwamish River flows and seasonal changes in salinity in Puget Sound.

The Seattle study area included the Lake Washington Ship Canal from Puget Sound to Lake Union, the shoreline of Elliott Bay, and the Duwamish Waterway.

General Observations

Elliott Bay and Puget Sound near the entrance to the Lake Washington Ship Canal (Shilshole Bay) had the gray-green color typical of natural waters of the area. The Ship Canal was dark green. The Duwamish Waterway appeared black near Elliott Bay changing to a blue-gray progressing upstream. Water depths in the bays and density in the other waterways prevented observance of bottom features.

Specific Observations - Lake Washington Ship Canal

E-1 Oil Slicks--Numerous small oil slicks were present in this general dock area [Fig. IV-26]. No active discharges were film-recorded.

E-2 Seattle Cedar Lumber Manufacturing Company [2-173]--This company reportedly discharges about 2,300 m^3/day (0.6 mgd) of cooling water through two outfalls to the canal. No indication of these discharges was recorded in July. The area was not imaged in April.

E-3 Turbidity--A moderate-sized field of turbidity appeared to originate from underneath a building at this shore indentation. No active discharge was detected. A small amount of oil was present in the turbidity field.

E-4 Oil Slicks--Numerous small oil slicks were present in these docking areas. The sources of oil were not distinguishable.

E-5 Unknown Discharge--Yellow-brown water discoloration was present immediately east of the Ballard Bridge. A small amount of oil was also

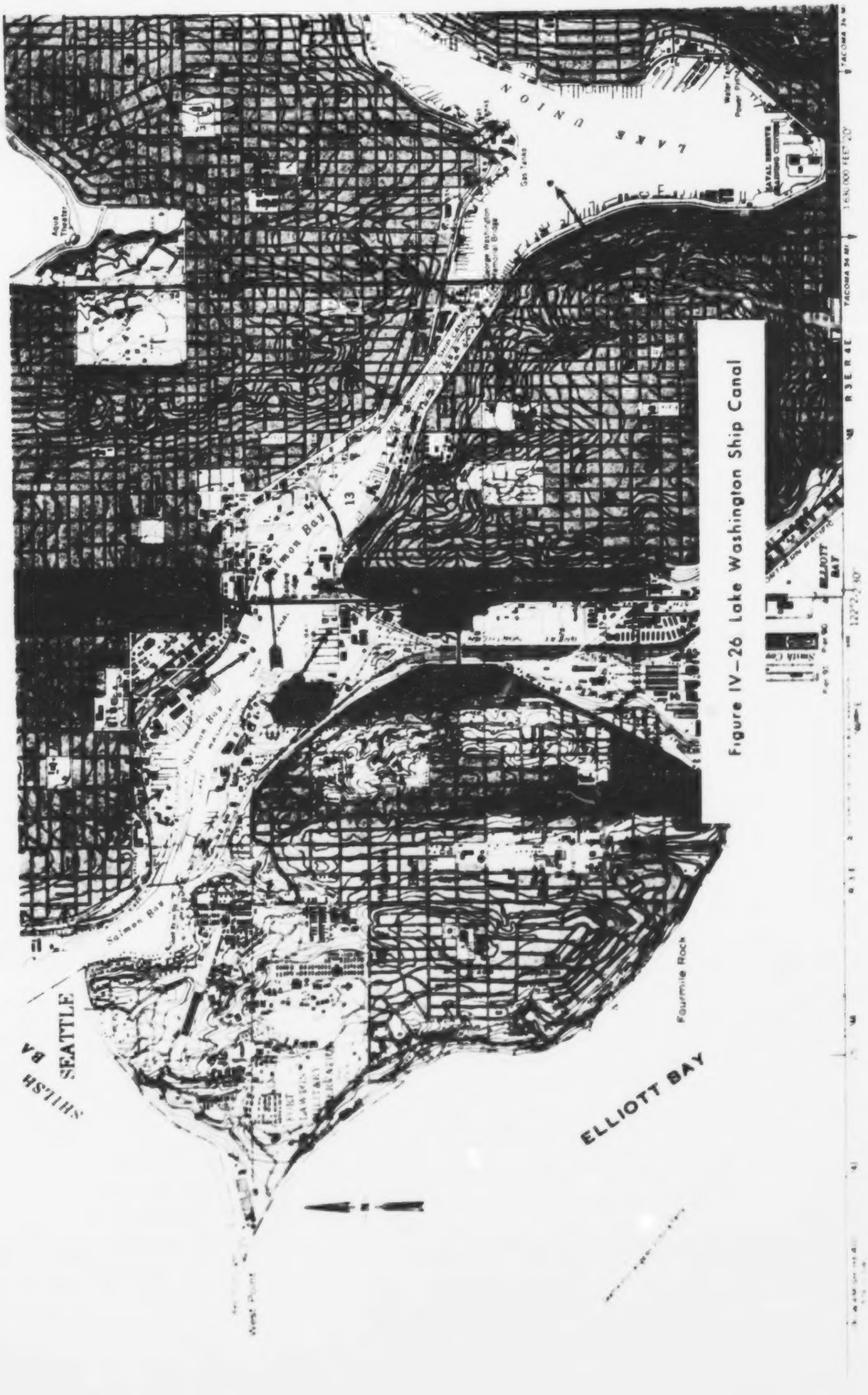

LAKE UNION
Salmon Bay
SHILSH BA
SEATTLE
ELLIOTT BAY
Fourmile Rock
West Point
Aqua Theater
Gas Tanks
NAVAL RESERVE TRAINING CENTER
ELLIOTT BAY
Pier 91
Pier 90
TACOMA
R 3 E R 4 E
122°22'30"

Figure IV-26 Lake Washington Ship Canal

present. The discoloration was nearly identical in color to wastewater contained in a pond near shore. No permit application was available for this location.

E-6 Oil Slick--A slick containing about 28 liters (7 gal.) of oil was recorded in this area of the canal. The source could not be determined.

E-7 Unknown Discharge--Yellow-brown water discoloration originated adjacent to the bridge and extended westward in the canal nearly to Salmon Bay. The source was not determined.

E-8 Graystone Corporation [2-265]--This facility reportedly discharges about 30 m^3/day (8,000 gpd) of boiler blowdown and autoclave wastewater to the canal through two outfalls. Yellow-brown water discoloration was recorded along the southwest side of the canal originating from the Graystone outfall.

E-9 Oil Slicks--Numerous slicks containing a total of about 150 liters (39 gal.) of oil were recorded in this area of Lake Union. The sources were not determined.

E-10 Turbidity--Several turbid areas along shore appeared to be caused by surface runoff.

Specific Observations - Elliott Bay

E-11 Seafood Processing Facilities--Six seafood processing facilities are located on the Elliott Bay waterfront near the main Seattle business district [Fig. IV-27]. Plant statistics and letter keys to locations in Figure IV-27 are listed below.

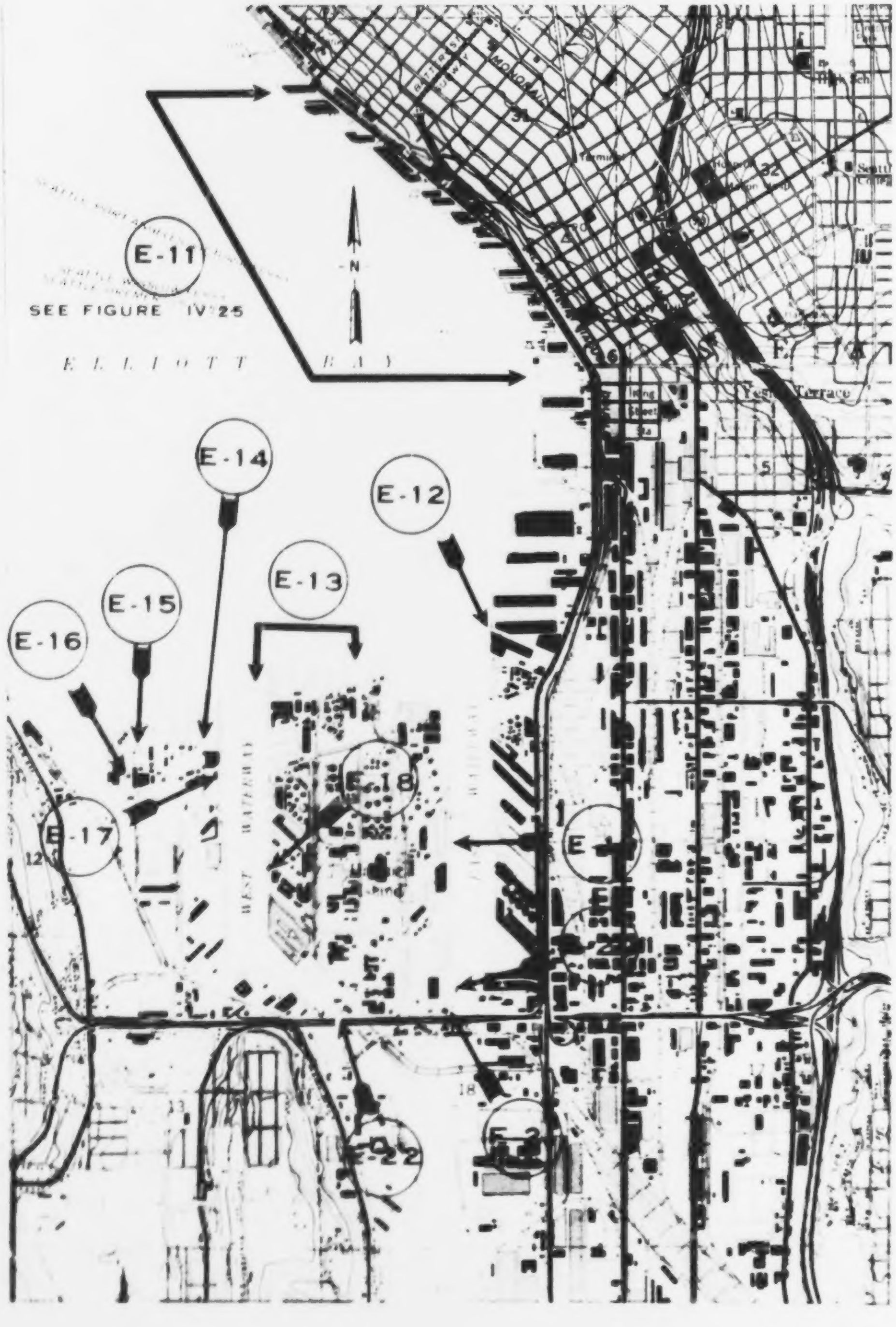

E-11
SEE FIGURE IV-25
N
ELLIOTT BAY
E-14
E-12
E-13
E-15
E-16
E-17
E-18
WEST WATERWAY
E-22

Figure IV-27 Elliott Bay and Harbor Island

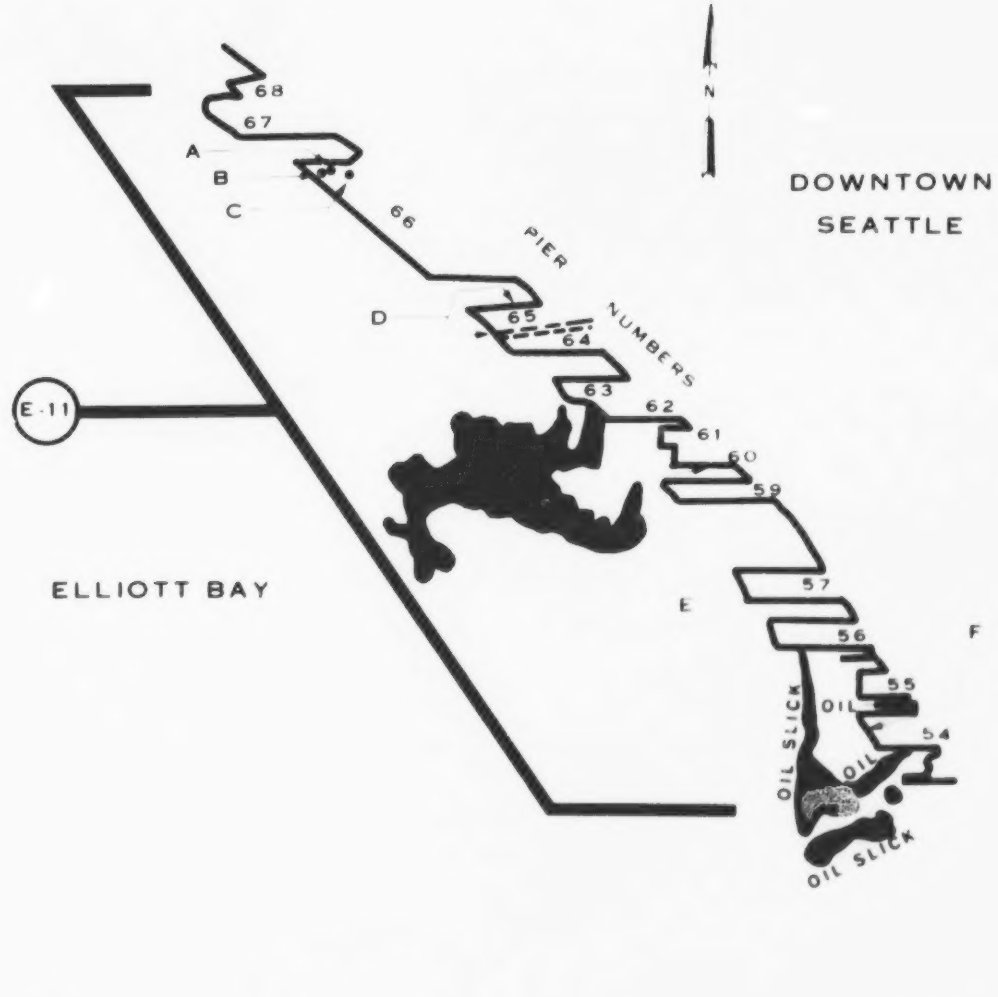
Map Key	Company	Permit Appl. No.	Discharge (m^3/day)	(gpd)
A	McCallum-Legas Fish Co.	2-259	23	6,000
B	Dressel Collins Fish Co.	2-231	105	27,600
C	Odion Sea Products	2-256	198	52,000
D	New England Fish Co.	2-243	160	42,000
E	Main Fish Co., Inc.	2-216	305	20,000
F	Washington Fish & Oyster Co.	2-221	76	80,000

There were no discharges detected at any of the plant locations. The permit applications indicated that each plant discharges through floor drains under the piers. Two oil slicks with about the same characteristics as refined (petroleum-base) oil were observed in the general area [Fig. IV-28].

E-12 Discoloration--Gray-brown water discoloration was present in this small dock area [Fig. IV-27]. It was very similar in color to the material being loaded onto a barge adjacent to the discoloration.

E-13 Todd Shipyards Corporation [2-652]--Todd Shipyards is located on Elliott Bay on the east edge of East Waterway [Fig. IV-27]. The facility has 58 discharge points, most associated with steam heating or drydock activities. Outfalls 001, 002 and 003 [Fig. IV-29] discharge an average of 1,100 m^3/day (0.028 mgd) of boiler blowdown and compressor cooling water. These discharges under the dock did not create visible plumes. A small oil slick was present in the vicinity.

A total of 21 essentially identical discharge points for condensate from the steam heating system were reported as Outfall type 004. The combined flow 1,300 m^3/day (0.35 mgd). These discharges are under docks around the water perimeter of the shipyards and were not visible.



DOWNTOWN SEATTLE
N
ELLIOTT BAY
E-11
PIER NUMBERS
68
67
66
65
64
63
62
61
60
59
57
56
55
54
A
B
C
D
E
F
OIL
OIL
OIL SLICK
OIL SLICK

Figure IV–28. Northeast Elliott Bay Waterfront

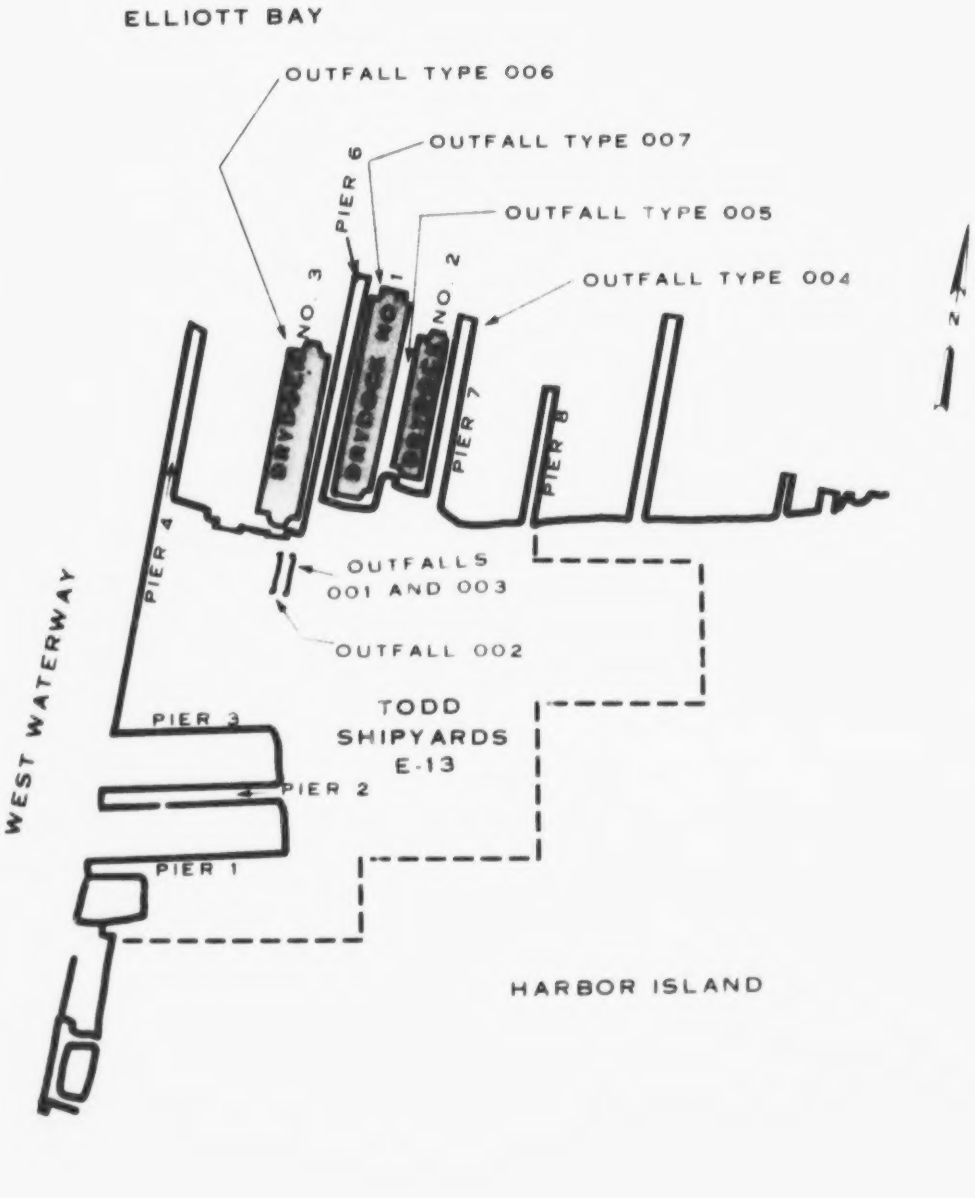

ELLIOTT BAY
OUTFALL TYPE 006
OUTFALL TYPE 007
OUTFALL TYPE 005
OUTFALL TYPE 004
PIER 6
DRYDOCK NO. 3
DRYDOCK NO. 1
DRYDOCK NO. 2
PIER 7
PIER 8
N
PIER 4
OUTFALLS 001 AND 003
OUTFALL 002
WEST WATERWAY
TODD SHIPYARDS E-13
PIER 3
PIER 2
PIER 1
HARBOR ISLAND

Figure IV-29. Todd Shipyards Corp.

The remaining 44 discharges were associated with drydock activities. Outfall type 005 was reported (RAPP application) as chemical treatment discharge points (4) for Drydock No. 2. Outfall type 006 was reported as the ten chemical treatment discharge points for Drydock No. 3. Outfall type 007 was reported as the 30 sand blasting discharge points for the three drydocks. In general, these discharge points are located on the perimeter of the floating drydocks. Drydock Nos. 1 and 2 were in use in July. No active discharges were recorded.

E-14 Lockheed Shipbuilding and Construction Company (Plant No. 2) [2-004]--Lockheed has two plants included in the same permit application. Outfall 001 is at Plant No. 1 discussed under E-18 below. Outfall 003 from Plant No. 2 is located at point E-14. It reportedly discharges 380 m^3/day (0.1 mgd) of air compressor cooling water. The above-surface outfall was active in July creating a gray-brown plume. Oil was present in the discharge creating several small slicks.

E-15 Lockheed Plant No. 2 (Continued)--Outfall 002, also an air compressor cooling water discharge, did not appear to be active.

E-16 Unknown Discharge--A yellow-gray wastewater was being discharged at [illegible] location creating a small concentrated plume of discoloration. The Lockheed permit application indicated this area was owned by the Wyckoff Company. No permit application was available.

Specific Observation - Duwamish Waterway

E-17 Lockheed Plant No. 2 (Continued)--No discharge was detected from the submetged Outfall 004, reportedly discharging a minor volume of metal rinse wastes. Outfall 005 is reported to be a small pond with a trench draining to West Waterway and discharging a small volume of metal rinse wastes. No pond or trench was observed.

Lockheed reported a total of 60 discharges from two floating drydocks (Typical Outfalls 006 and 007). These discharges reportedly contain metal rinse wastes in small volumes.

E-18 Lockheed Shipbuilding and Construction Company (Plant No. 1) [2-004]--Outfall 001 reportedly discharges about 450 m^3/day (0.12 mgd) of air compressor cooling water. The discharge location in West Waterway was obscured by a docked ship. No plumes or discoloration were detected in the area.

E-19 Oil Slicks--Numerous oil slicks were recorded in this area of East Waterway [Fig. IV-27]. The sources could not be determined.

E-20 Unknown Discharge--Yellow-brown water discoloration was detected along the west shore of East Waterway at this location; a pond on shore contained wastewater very similar in color. No active discharge was recorded.

E-21 Potential Discharge--A small yellow-gray area of discoloration was located in a shoreline indentation of East Waterway adjacent to the north edge of the Spokane Street Bridge. No active discharge was recorded.

E-22 Unknown Discharge--A gray-brown plume was present in this small area of the West Waterway in July. No source was detected.

E-23 Unknown Discharge--A concrete structure on the west side of the Duwamish Waterway [Fig. IV-30] appeared to be discharging a yellow-brown wastewater creating a small area of discoloration. The source of the wastewater was not detectable.

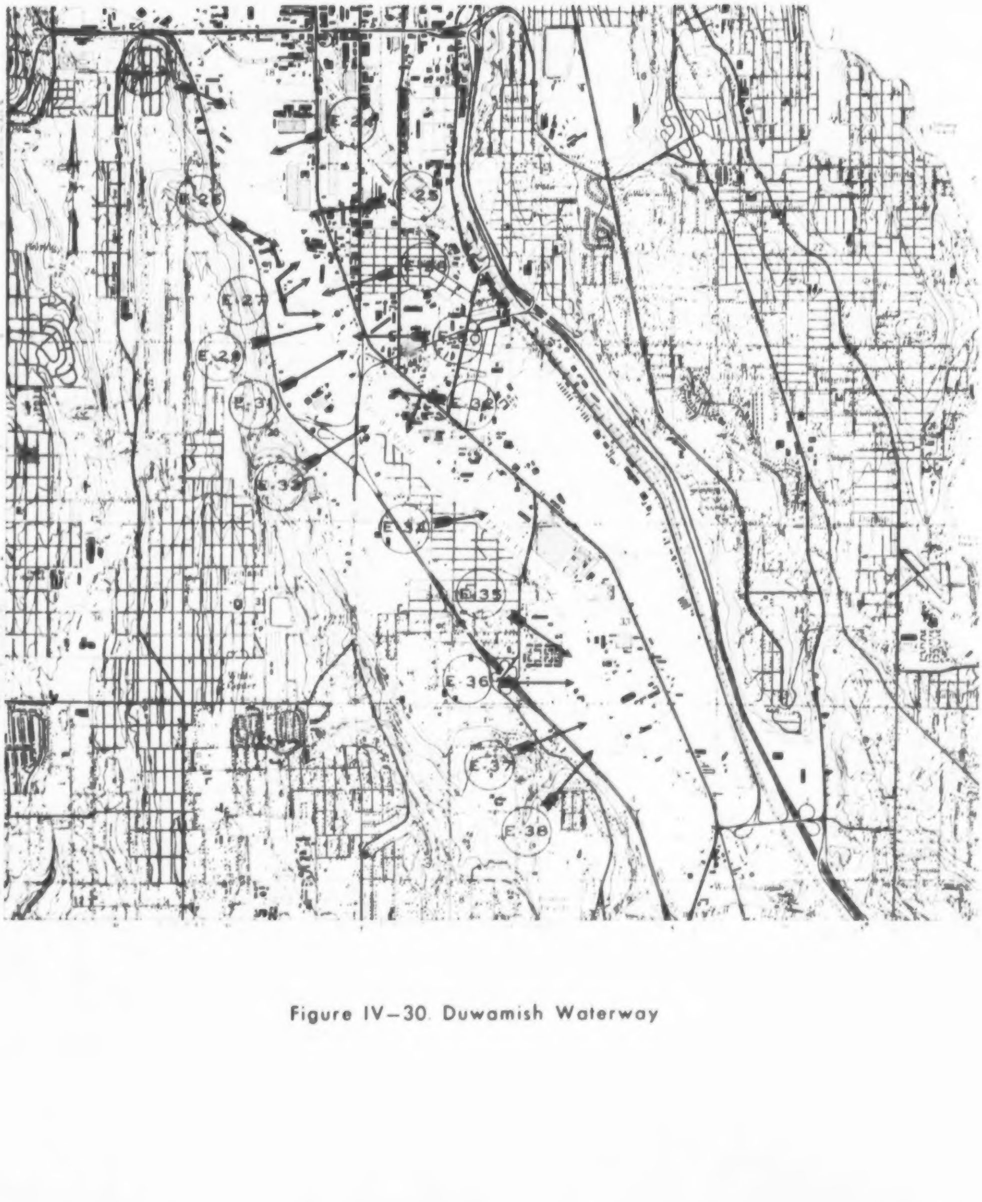

E-24
E-25
E-26
E-27
E-31
E-32
E-33
E-34
E-35
E-36
E-37
E-38

Figure IV–30. Duwamish Waterway

E-24 Outfall Structure--An outfall structure was present adjacent to a water filtration plant. No discharge was detected.

E-25 Liquid Carbonic Corporation [2-079]--Cooling water from the production of carbon dioxide is discharged through a single outfall to the east end of a boat slip. The average discharge rate is 5,300 m^3/day (1.4 mgd). No sign of the discharge was detected.

E-26 Ideal Cement Company [2-269]--Air compressor cooling water, averaging 38 m^3/day (0.01 mgd), is reportedly (RAPP application) discharged to a side channel of the Duwamish Waterway through two outfalls in the cement storage area. No indication of these minor discharges was recorded. Gray water discoloration in the main channel of the Duwamish Waterway originated from the vicinity of the cement mill. Wastewaters from the mill are reportedly connected to the municipal sewer system.

E-27 Oil Slicks--Numerous large slicks with a calculated content of nearly 575 liters (150 gal.) of refined oil were present in this area of the Duwamish Waterway. The source of the oil was not detected.

E-28 Northwestern Glass Company [3-246]--Cooling water averaging 300 m^3/day (0.075 mgd) is discharged to Duwamish Waterway through two outfalls, one of which is submerged at high tide. Contaminated cooling water and other wastewaters are reportedly (RAPP application) discharged to municipal sewers. A yellow-brown plume was present along shore. The two known discharges were not specifically detected.

E-29 Kaiser Gypsum Company [3-075]--This facility that manufactures gypsum wallboard and plaster reported (RAPP application) three discharges. Submerged Outfall 001 discharges an average of 640 m^3/day (0.17 mgd) of wastewater from a wet scrubber used for gypsum dust control.

Outfalls 002 and 003 have a single above-water discharge point and discharge about 150 m^3/day (0.04 mgd) of cooling water and boiler blowdown. Two distinct adjacent yellow-gray plumes were recorded in the vicinity of Outfall 001. No indication of the discharge from Outfalls 002 and 003 was observed.

E-30 Glacier Sand and Gravel Company [2-011]--Gray water discoloration surrounded the outfall of this concrete mixing facility on Slip No. 2 of Duwamish Waterway. Wastewater resulting from the washing of transit mixer trucks, the central mixer, and the yard is reportedly batch discharged once per day for a 15 to 20 minute period. Average volume is 250 m^3/day (0.065 mgd).

E-31 Kaiser Gypsum Company (Continued)--Kaiser's accessory plant on the south side of Slip No. 2 reportedly discharges about 3 m^3/day (800 gpd) of cooling water to the slip. No discharge was observed.

E-32 Oil Slicks--Numerous small oil slicks were recorded in these boat slips [Fig. VI-30]. The sources could not be determined.

E-33 Concrete Mix Facility--Runoff from this facility was causing small fields of turbidity in the Duwamish Waterway. A permit application was not available.

E-34 Potential Discharge--Dark gray-brown water discoloration was detected along the east shoreline of Duwamish Waterway. No discharge was visible.

E-35 Unknown Discharge--A small yellow-gray area of turbidity was recorded along the west bank of the Duwamish Waterway. It appeared that wastewater was discharged on the bank of the waterway and then dispersed into the main channel. The source of the wastewater was not detected.

E-36 Unknown Discharges--In April two adjacent yellow-brown discharges were observed entering the Duwamish Waterway during a low tide condition. Only slight discoloration was recorded during a high tide condition in July. The north discharge [Fig. IV-30] was traceable to a small ditch flowing through a large auto salvage yard.

E-37 Outfalls--Three pipes, each an estimated 60 cm (24 in.) in diameter, entered the Duwamish Waterway at this location. None of the pipes was observed discharging.

E-38 Unknown Discharge--An outfall with an estimated diameter of 180 cm (72 in.) and an elevation slightly above the mean low water line was active in April creating a yellow-gray field of discoloration in the Duwamish Waterway. The outfall was completely submerged in July.

TACOMA (AREA F)

Descripiton of Area

Tacoma is located on Commencement Bay at the south end of the main body of Puget Sound [Fig. IV-1]. The city, with a population of about 175,000, is an industrial center.

Commencement Bay is one of the world's largest naturally protected harbors. The average depth of the harbor is 45 to 55 m (150 to 180 ft). The southeast end of the Bay has been dredged into a number of deep waterways to facilitate ship docking. The Puyallup River, with an average flow of about 100 m^3/sec (3,500 cfs), enters the Bay through one of these waterways.

Strong tidal action combined with surface freshwater outflow from the Puyallup River produces regular flushing of the entire Bay. Pollutants introduced into the Bay are thus rapidly dispersed except in the confined harbor waterways.

General Observations

Background waters of Commencement Bay were a natural gray-green. Extensive areas of light tan turbidity were present throughout the Bay. This turbidity appeared to originate from two sources: The Puyallup River and the American Smelting and Refining Company at Ruston. The Puyallup River was tan [Fig. IV-31]. Turbidity from the river inflow was dispersing along the southwest shoreline of Commencement Bay. Tidal action also transported turbidity into the adjacent dredged waterways. The overall color of these waterways was dark green. Bottom features of the waterways were not visible.

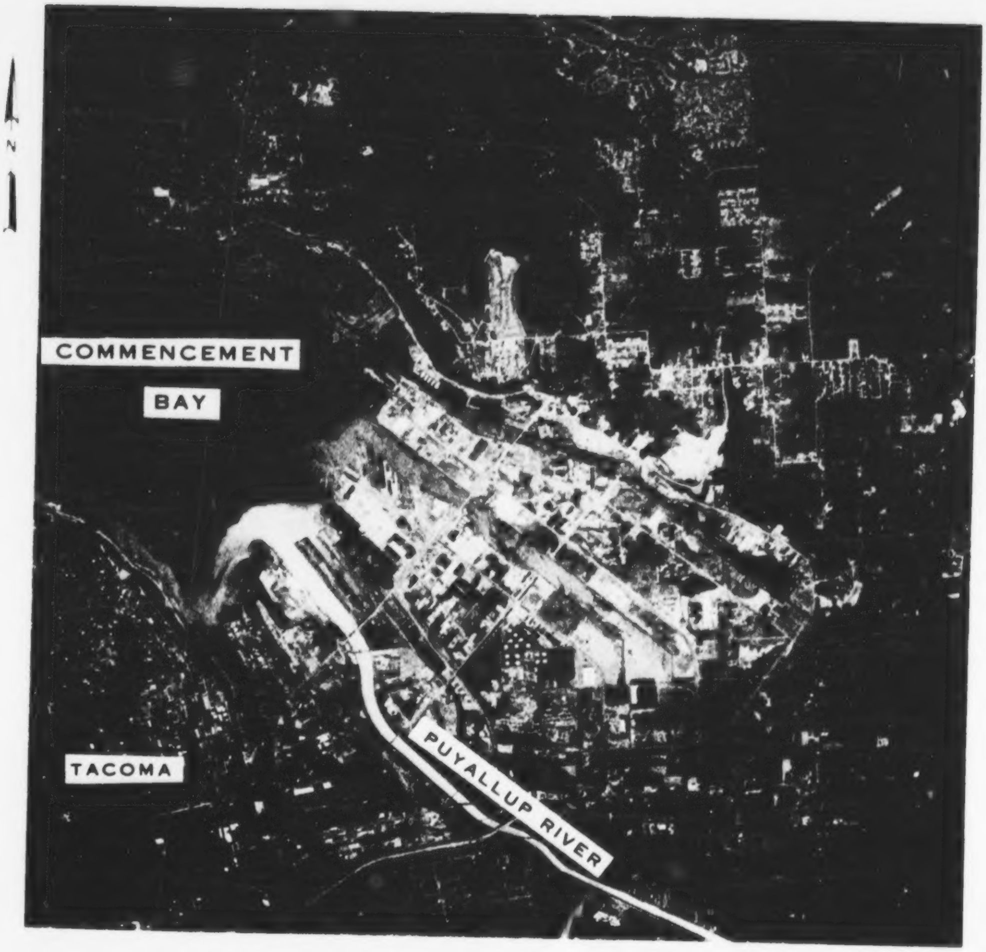

N
COMMENCEMENT
BAY
TACOMA
PUYALLUP RIVER

Figure IV-31. Tacoma Harbor — Commencement Bay

Specific Observations - Ruston Area

F-1 American Smelting and Refining Company [2-016]--The largest copper smelter on the west coast is operated by this company on the west shore of Commencement Bay at Ruston [Fig. IV-32]. The company reported six wastewater discharges with a combined flow rate of 45,000 m^3/day (12 mgd).

Outfall 001 discharges an average of 12,000 m^3/day (3.2 mgd) of cooling and process wastewater from a contact sulfuric acid plant. The outfall discharges to a small dispersion pond on shore [Fig. IV-33]. Effluent from the pond seeps through a slag fill to Commencement Bay. In April the open end of a pipe estimated to be 2 m (6 ft) in diameter was observed terminating offshore in Commencement Bay northeast of the dispersion pond. A straight line extension inland of this pipe would pass just southeast of the pond. In July the pond had been enlarged and extended over the straight line projection of the pipe. No information on the pipe was included in the permit application. Heavy concentrations of a yellowish-green substance were observed in Commencement Bay in the vicinity of this pipe in both April and July. Lighter concentrations of this substance in discontinuous patches discolored the Bay offshore for a distance greater than that photographed [Fig. IV-33].

Outfall 002, a wood covered ditch terminating at the Bay shoreline inside the copper dock area [Fig. IV-33], serves the copper converting and anode casting process areas. Average discharge is reported as 14,000 m^3/day (3.7 mgd). No discharge was observed in either April or July. The ditch is located in a slag fill and the discharge to the Bay may occur as seepage through the fill.

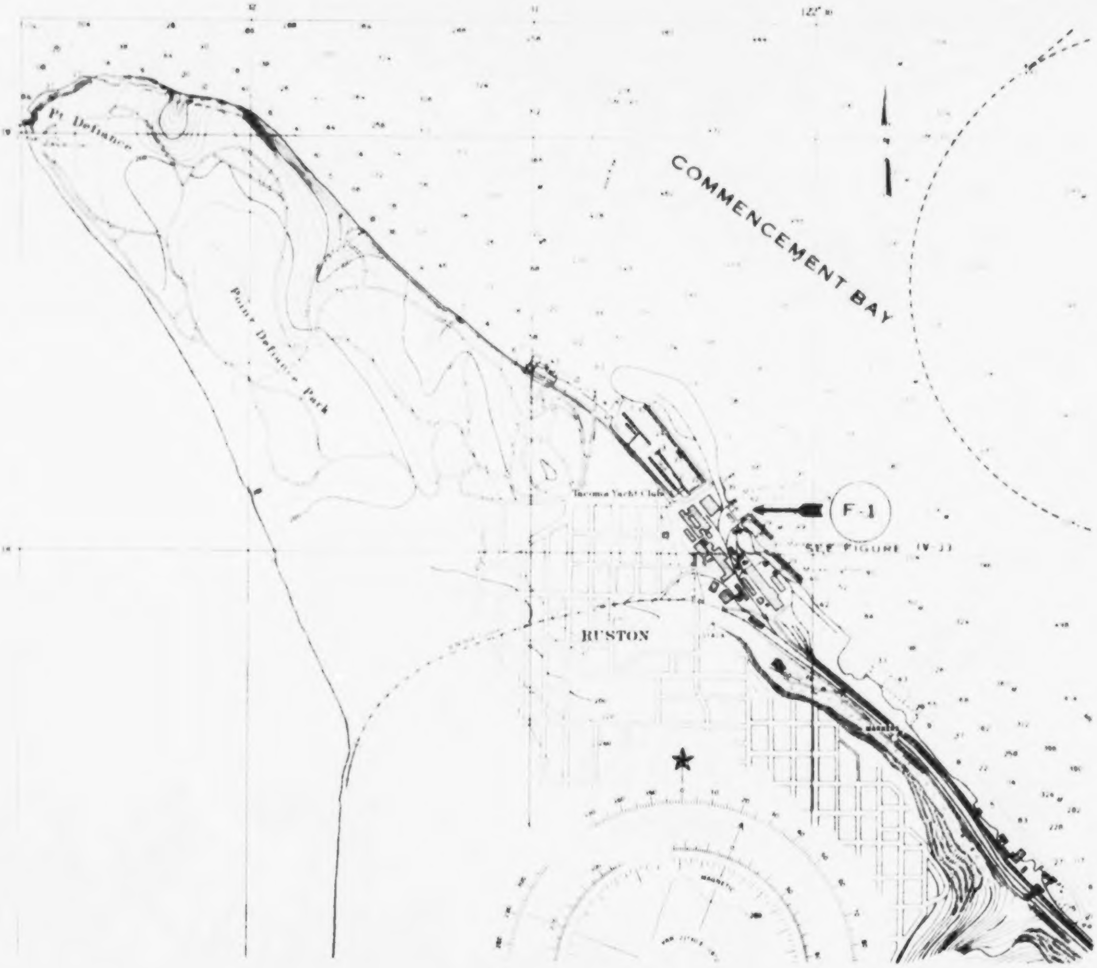

COMMENCEMENT BAY
Pt Defiance
Point Defiance Park
Tacoma Yacht Club
F-1
SEE FIGURE IV-33
RUSTON
MAGNETIC

Figure IV–32 Ruston Area

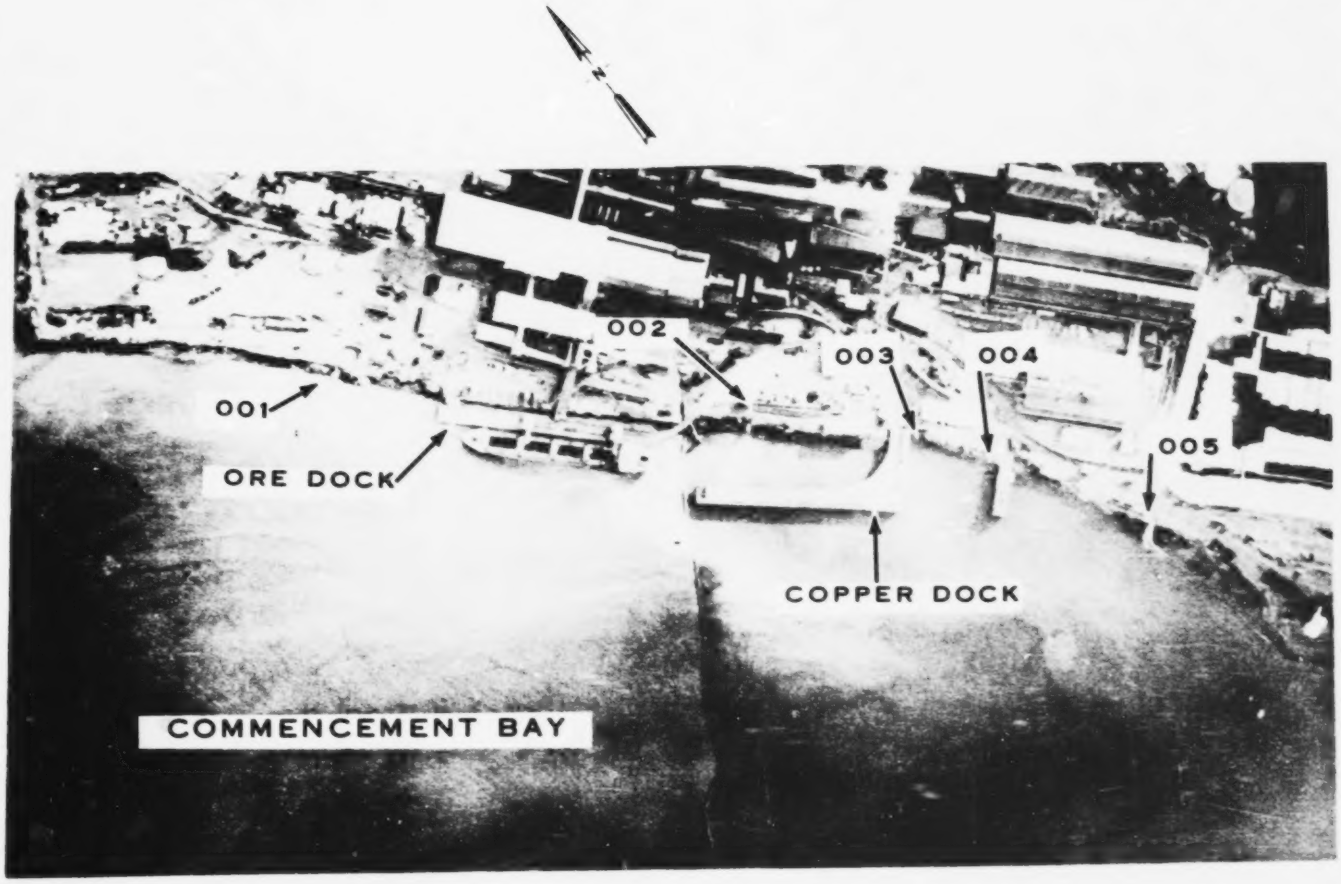

N
001
002
003
004
005
ORE DOCK
COPPER DOCK
COMMENCEMENT BAY

Figure IV—33. American Smelting and Refining Company

Outfall 003, with an average flow of only 1,100 m^3/day (0.3 mgd), serves electrolyte purification and precious metal recovery operations. The outfall is a 30 cm (12 in.) diameter tile line terminating below low water level beside the copper dock [Fig. IV-33]. A small yellowish-green discharge was observed during both flights.

No discharge was observed from Outfall 004, a 60 cm (24 in.) pipe terminating above high water. This outfall reportedly discharges 340 m^3/day (0.09 mgd) of wastewater from electrolyte purification and copper casting operations.

Outfall 005 discharges air compressor cooling water averaging 1,100 m^3/day (0.3 mgd) to a large Tacoma sewer outfall terminating in deep water near shore. At the shoreline a manhole on this outfall is equipped with a "storm overflow pipe." During both missions a discharge of considerable force was recorded from this overflow pipe. An area of the Bay surface about 3 x 6 m (10 x 20 ft) was disturbed by this discharge.

Slag from the reverberatory furnaces is disposed of by granulation and landfill on a small peninsula constructed entirely of slag northwest of the plant [Fig. IV-32]. Saltwater averaging 17,000 m^3/day (4.5 mgd) is used in transporting and granulating the slag. This wastewater drains through the slag into the Bay (Outfall 006). The granulator was active during both missions.

Specific Observations - Tacoma Harbor

F-2 Union Oil Company of California [2-028]--This facility is a petroleum bulk station and terminal with no manufacturing processes.

Wastewaters (type unknown) pass through a 2.1 m^3 (550 gal.) oil separator before discharge through a 10 cm (4 in.) diameter pipe to City Waterway [Fig. IV-34]. The volume was not reported. A skimmer in the waterway surrounding the discharge point was observed to be ineffective in containing a moderate amount of oil. In April an oil slick extended 150 m (500 ft) along the east bank of the waterway toward Commencement Bay. In July tidal action had transported a similar slick about 120 m (400 ft) south in the waterway.

F-3 Mobil Oil Corporation [3-028]--This facility is a wholesale distribution terminal for refined petroleum products and is located adjacent to the Union Oil terminal [Fig. IV-34]. Surface runoff from the terminal passes through a modified API oil separator before discharge to City Waterway. A skimmer was present around the discharge point but it was not effectively containing all the oil. Some oil contributed to the slick from the Union Oil facility, and the combined volume of oil was estimated to be 12 to 14 liters (3 to 4 gal.).

F-4 Concrete Mix Plant--A concrete mix plant with a fleet of transit-mix trucks is located on the west bank of City Waterway [Fig. IV-35]. No permit application was available. An area at the plant on the south side of the swing bridge is used for washing out the trucks. A truck was observed in this area in July. An area of the waterway about 2 x 6 m (6 x 20 ft) was gray in color.

F-5 St. Regis Paper Company, Tacoma Door Plant [3-158]--This plant reported the discharge of about 500 m^3/day (0.13 mgd) of cooling water through one outfall to the Wheeler-Osgood Waterway, a branch of City

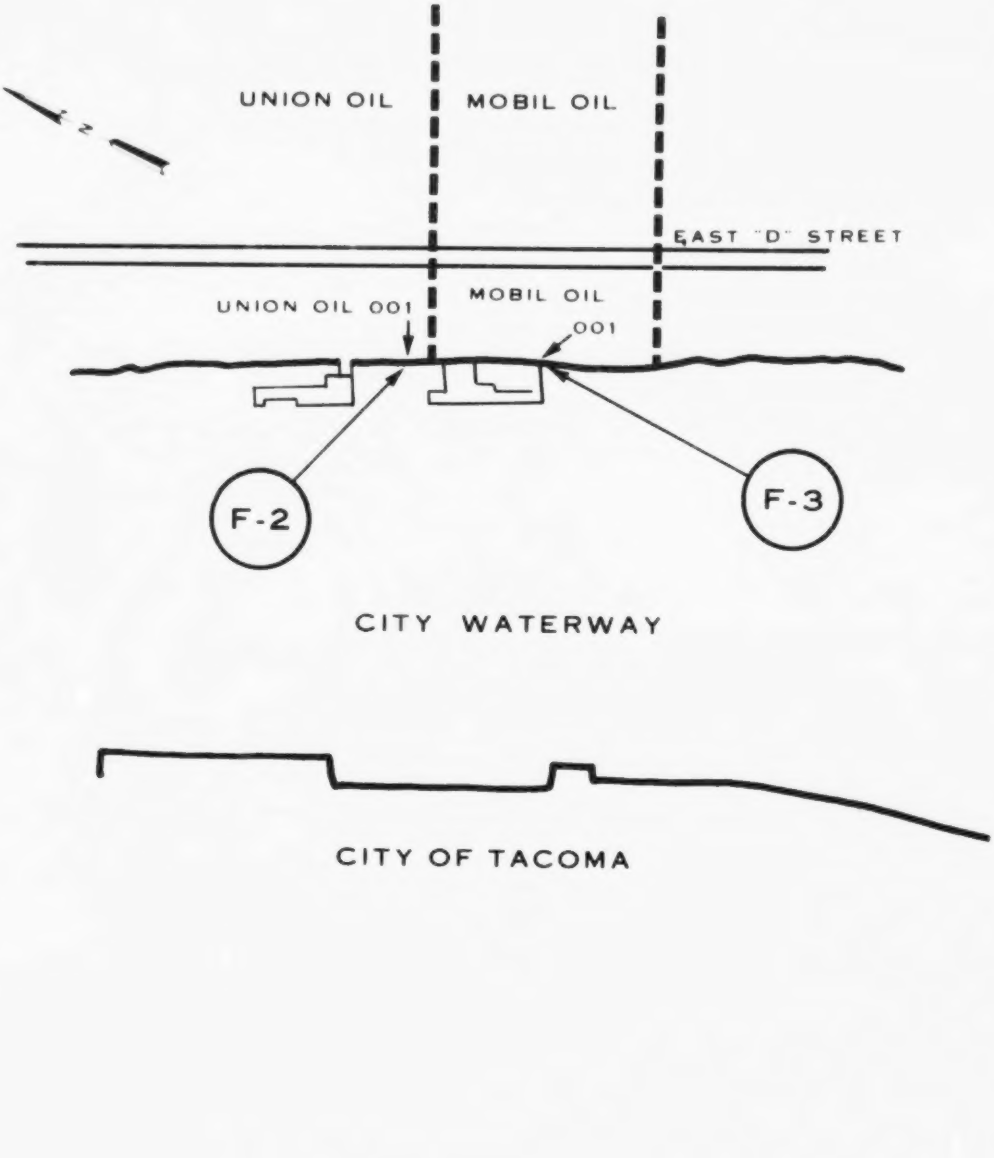

N
UNION OIL
MOBIL OIL
EAST "D" STREET
UNION OIL 001
MOBIL OIL
001
F-2
F-3
CITY WATERWAY
CITY OF TACOMA

Figure IV-34. City Waterway

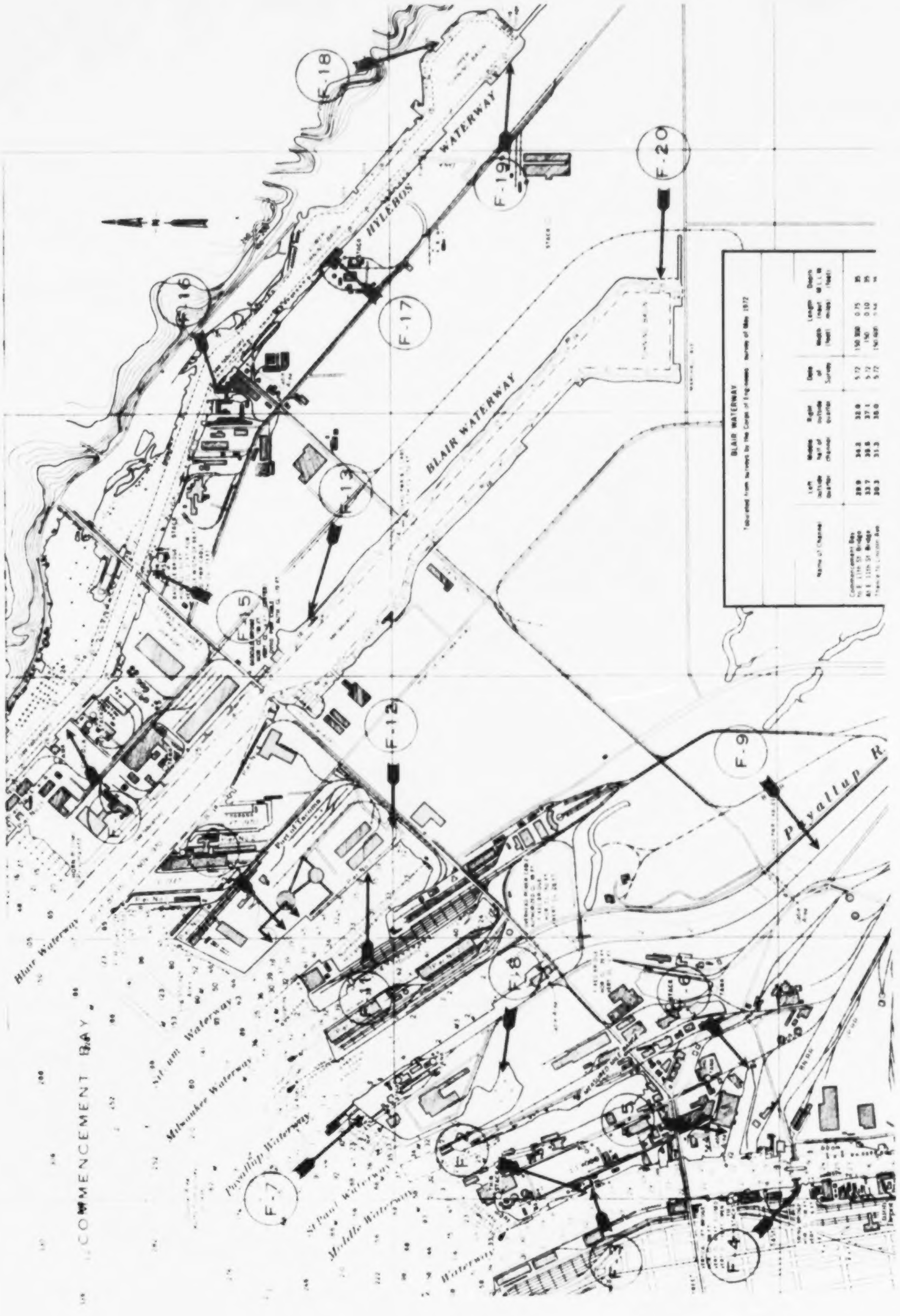

COMMENCEMENT BAY
Blair Waterway
Sitcum Waterway
Milwaukee Waterway
Puyallup Waterway
St Paul Waterway
Middle Waterway
Waterway
Port of Tacoma
BLAIR WATERWAY
HYLEBOS WATERWAY
Puyallup R.
BLAIR WATERWAY
F-3
F-4
F-5
F-6
F-7
F-8
F-9
F-11
F-12
F-13
F-15
F-16
F-17
F-18
F-19
F-20

Figure IV-35 Tacoma Harbor

Waterway. The outfall did not appear to be active in April. In July a small light brown plume was observed in the vicinity of the outfall.

F-6 Wheeler - Osgood Waterway--A plume from an unknown source that appeared to be in the southeast corner of this waterway was recorded by both missions. The plume, about 2 m x 60 m (6 ft x 200 ft), was greenish-brown in April. Some oil was present in July.

F-7 St. Regis Paper Company, Tacoma Kraft Pulp and Paper Mill [2-045]--This mill is located on Commencement Bay at the mouth of the Puyallup Waterway (Puyallup River) [Fig. [illegible]-36]. The mill reported five outfalls. The location of Outfall 001, which discharges about 150 m^3/day (0.04 mgd) of sanitary wastes, was not reported.

Outfall 002 discharges to Puyallup Waterway an average of 3,100 m^3/day (0.83 mgd) of auto wash wastewaters and filter backwash from a water treatment plant. No discharge was observed.

Outfall 004 is the main process wastewater discharge. This effluent, averaging 108,000 m^3/day (28.5 mgd), receives primary treatment before discharge through a near-surface port on a "level control silo" located about 18 m (60 ft) offshore in Commencement Bay. White foam surrounded the discharge point but it was contained by log booms. Flotsam and a small amount of oil were present inside the booms.

Outfall 005, a 120 cm (48 in.) pipe terminating in 6 m (20 ft)of water, is an auxilliary process waste outfall. It did not appear to be active. No discharge was observed from Outfall 006, a storm drain and emergency hydraulic barker outfall.

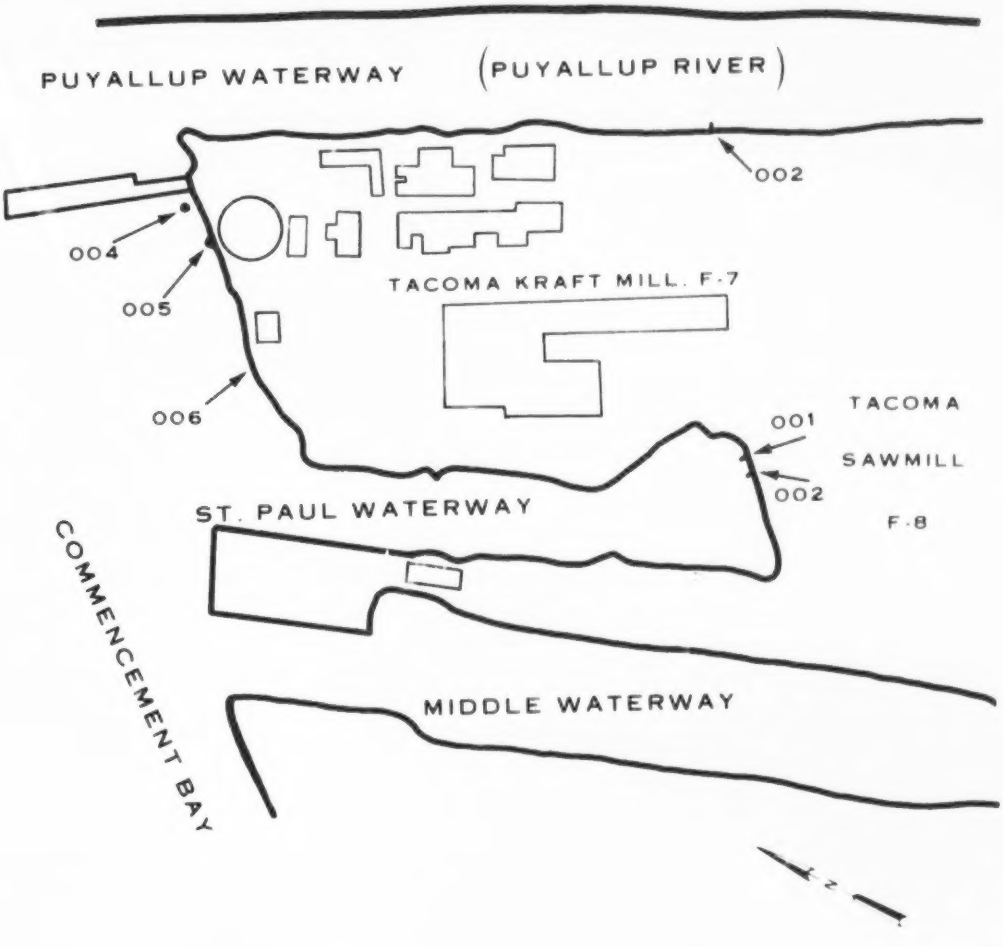

PUYALLUP WATERWAY
(PUYALLUP RIVER)
002
004
005
TACOMA KRAFT MILL. F-7
006
TACOMA
001
SAWMILL
002
F-8
ST. PAUL WATERWAY
COMMENCEMENT BAY
MIDDLE WATERWAY
N

Figure IV-36. St. Regis Paper Company

F-8 St. Regis Paper Company, Tacoma Sawmill [3-157]--This mill reported the discharge of about 5,000 m^3/day (1.3 mgd) of cooling water and process wastewater through two surface outfalls to St. Paul Waterway [Fig. IV-36]. Incomplete photographic coverage precluded full study of the waterway. In July a dark brown plume originating in the area of the discharges was moving northward in the waterway beyond the photographic limit.

F-9 Municipal Wastewater Discharge--An outfall adjacent to a municipal wastewater treatment plant was active during both missions. In July the yellowish-gray plume about 12 m (39 ft) wide was flowing downstream in the Puyallup River for about 550 m (1,800 ft).

F-10 Storm Drains--What appeared to be three storm drains entered Sitcum Waterway at the points indicated [Fig. IV-35]. Construction was in progress in the area. No outflow from the drains was observed.

F-11 Cascade Pole Company [2-071]--This company treats wood products with preservatives. Wastewaters averaging less than 260 m^3/day (0.07 mgd) are discharged to a Port of Tacoma storm sewer that discharges to Sitcum Waterway under Pier 7. In April a gray ribbon-like plume originated in the vicinity of the storm drain and extended about 160 m (520 ft) southward to the end of the waterway. A small amount of oil was present in the plume. The company's permit application indicated there may be other industrial effluents from other plants discharged to this storm sewer. No other permit applications were available for this general location.

F-12 Potential Discharge--The water surface under Pier No. 7 at this location [Fig. IV-35] as viewed through an open area in the pier was observed to be disturbed, indicating the probable presence of an active outfall. A yellowish-gray discoloration was entering Sitcum Waterway from under the pier.

F-13 Domitar Chemicals, Inc., Lime Division [2-068]--This facility manufactures quicklime and hydrated lime from raw limestone. Wastewaters generated primarily by cooling kiln bearings with some washing of raw limestone are discharged through one outfall to Blair Waterway near the facility dock [Fig. IV-35]. The flow rate is about 190 m^3/day (0.05 mgd). In July there were indications of significant leaching from stockpiles into the waterway.

F-14 Hooker Chemical Corporation [3-022]--This chemical plant manufactures chlorine, caustic soda, trichlorethylene and ammonia. Water use for cooling purposes is reported to be 66,000 m^3/day (17.49 mgd) with only 450 m^3/day (0.12 mgd) used for process water. Wastewater is discharged through two outfalls to Hylebos Waterway. The permit application did not define the process area served by each outfall.

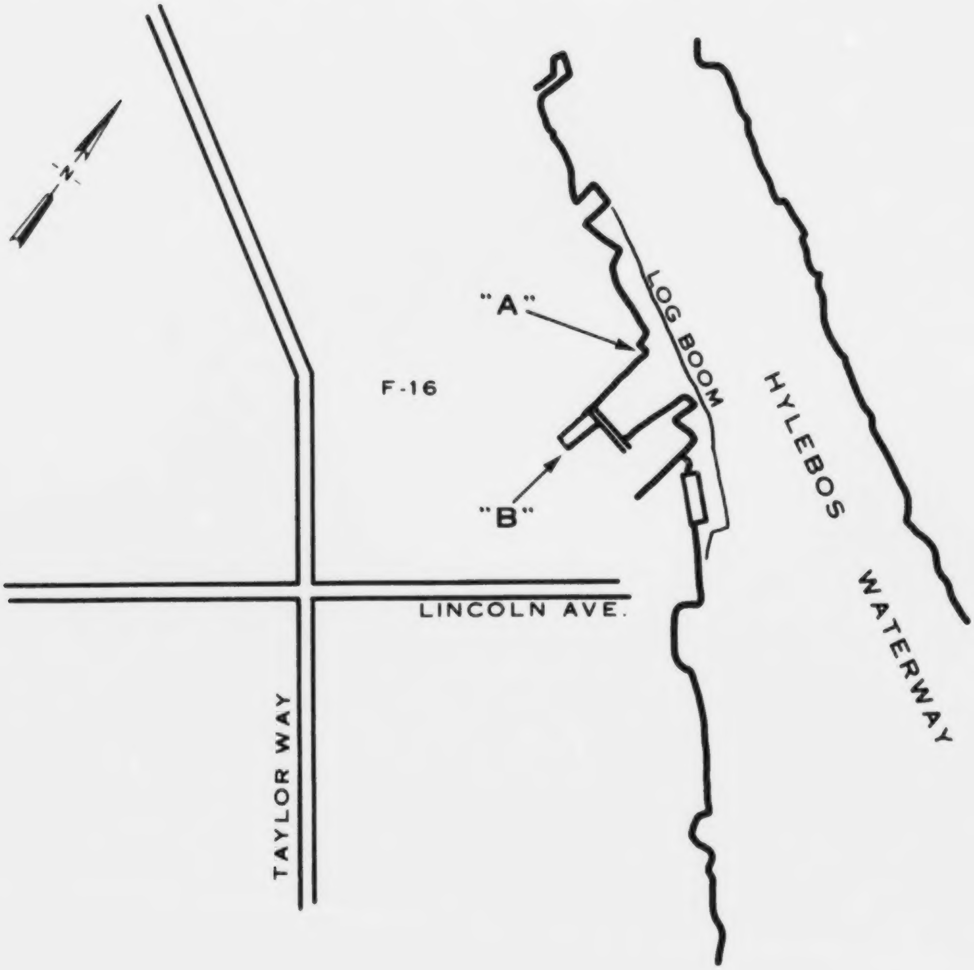
Outfall 001 is a near-surface discharge under Dock No. 1. No discernible discharge was recorded but some discoloration was present between the dock and shore. The flow rate is 18,000 m^3/day (4.8 mgd). About 47,000 m^3/day (12.4 mgd) is discharged through Outfall 002, a 1 m (3 ft) diameter pipe submerged in 8 m (25 ft) of water between the two docks. In July a gray plume about 240 m (800 ft) long with an average width of 4 m (13 ft) extended from the vicinity of Outfall 002 up the Hylebos Waterway along the western bank.

F-15 City of Tacoma, Department of Public Utilities, Steam Plant No. 2 [2-200]--This two-unit oil-fired steam electric plant has four outfalls. A 38 cm (15 in.) storm sewer, a sanitary sewer, and a 30 cm (12 in.) cooling water line from the transformers all have minor flows. The main outfall discharges about 350,000 m^3/day (93 mgd) of salt water used for cooling purposes. The outfall is a 1.2 m (48 in.) pipe terminating between high and low tide level with a downward discharge direction. The only discharge visible was from the main outfall. An area of the Hylebos Waterway about 4 x 24 m (13 x 79 ft) was disturbed by the force of the discharge. Bubbles and foam were visible for another 30 m (100 ft) on an incoming tide pushing the discharge up the waterway.

F-16 Potential Discharges--A blue-gray discoloration that appeared to originate from two probable outfalls located at points "A" and "B" [Fig. IV-37] was recorded in Hylebos Waterway. The discoloration was contained along the south bank by an extensive log boom. No permit application was available for this location.

F-17 Pennwalt Corporation [3-123]--This plant manufactures chlorine, caustic soda and hydrochloric acid. Process and cooling waters averaging 32,000 m^3/day (8.45 mgd) are discharged to Hylebos Waterway through a single outfall terminating in a multi-pipe discharge manifold under the dock at a 3 m (10 ft) depth [Fig. IV-35]. There was no evidence of discharge.

F-18 Turbidity--An excessive amount of turbidity was recorded in April along the northern shore of the Hylebos Upper Turning Basin [Fig. IV-35]. The source of this turbidity could not be identified.



N
"A"
LOG BOOM
F-16
HYLEBOS
"B"
WATERWAY
LINCOLN AVE.
TAYLOR WAY

NOTE - "A", "B" - PROBABLE OUTFALLS

Figure IV–37. Hylebos Waterway

F-19 Glacier Sand and Gravel Company [3-086]--Wastewater resulting from the washing of transit-mix trucks, the concrete mixer and the yard at this concrete ready-mix plant is discharged through a ditch to the southwest side of the Hylebos Upper Turning Basin. The discharge is intermittent over a four-hour period.

F-20 Potential Thermal Discharge--The Infrared Line Scanner imagery indicated the water surface in the turning basin at the end of Blair Waterway [Fig. IV-35] was significantly warmer than the rest of the waterway. The source could not be determined. This area was not photographically covered.

BREMERTON (AREA G)

Description of Area

Bremerton, with a metropolitan area population of about 70,000, is located on the Kitsap Peninsula between the Hood Canal and Puget Sound west of Seattle [Fig. IV-1]. The city fronts on Sinclair Inlet and Port Washington Narrows [Fig. IV-38]. Port Orchard connects these waterways to Puget Sound west of Bainbridge Island.

Water depths in Sinclair Inlet adjacent to the city vary from 10 to 20 m (33 to 66 ft). Port Washington is much deeper and provides tidal flushing of the area with Puget Sound water.

The Puget Sound Naval Shipyard is the major employer and industrial facility in the area.

General Observations

Waters of Sinclair Inlet were natural gray-green and were free of visible turbidity.

Specific Observations

Puget Sound Naval Shipyard [2-241]--This facility reportedly has 17 outfalls with a combined flow of about 38,000 m^3/day (10 mgd). No discharges from these outfalls were visible nor were any other discharges detected. In April an oil slick was recorded originating at aircraft carrier No. 20 which was docked at mooring 7. The slick contained about 145 liters (38 gal.) of oil.

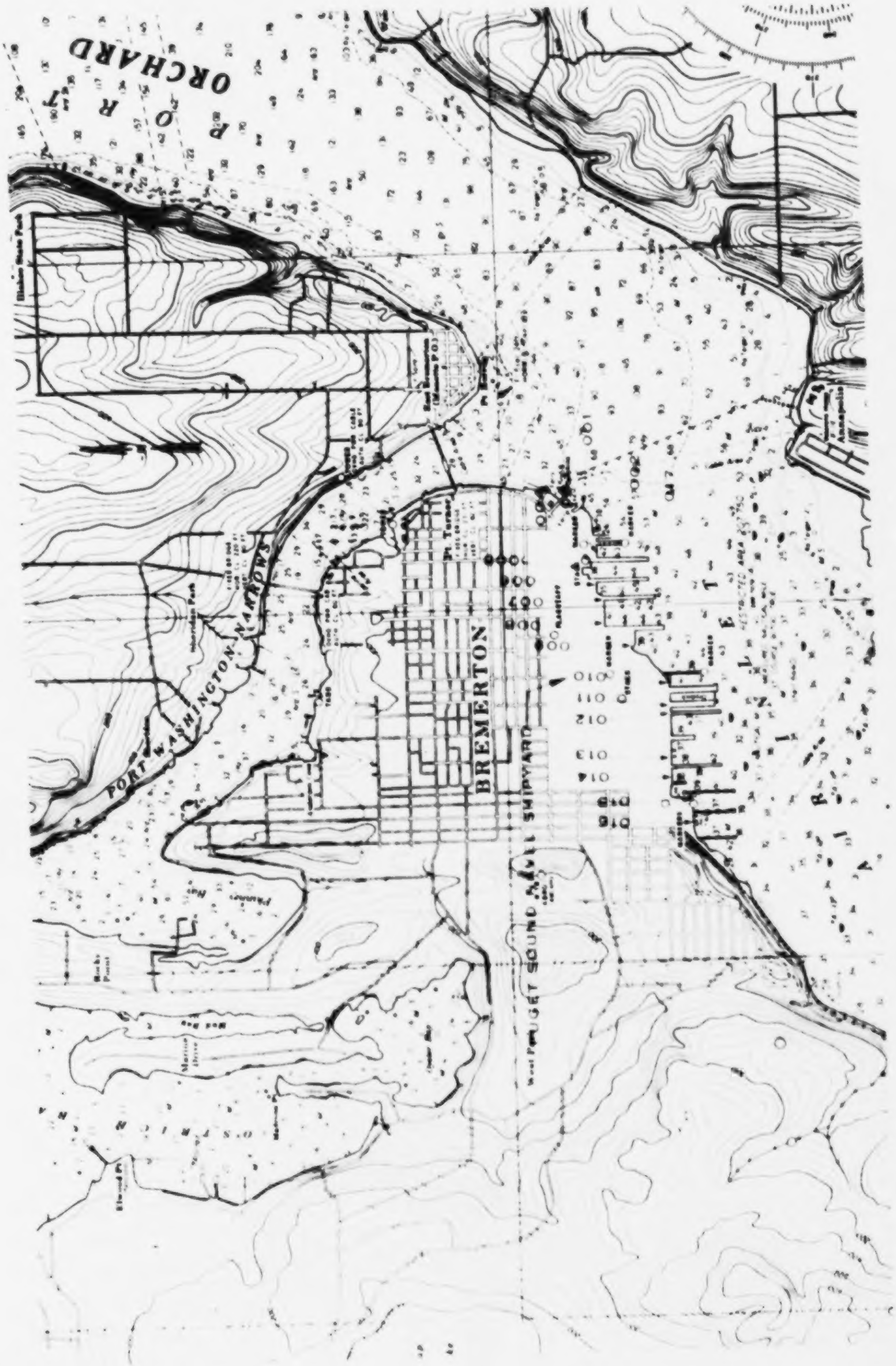

PORT ORCHARD
BREMERTON
PORT WASHINGTON NARROWS
PUGET SOUND NAVAL SHIPYARD
INLET

Figure IV–38 Bremerton Area

SHELTON (AREA H)

Description of Area

Shelton is located on Oakland Bay, a southwest arm of Puget Sound [Fig. IV-1]. Goldborough Creek, a small stream, enters the Bay in Shelton [Fig. IV-39]. The Bay is shallow near the city and industrial areas, deepening to more than 20 m (66 ft) in the open water areas.

The city has a population of about 6,000. The economy depends on the wood products industry.

General Observations

The shallow harbor areas of Oakland Bay appeared black with extensive areas of turbidity. Numerous pilings and log holding areas covered much of the harbor. Bottom features were not visible.

Specific Observations

The Simpson Timber Company and ITT Rayonier reported a total of 17 wastewater discharges to Oakland Bay. Numerous pilings, dolphins, log booms and log rafts were present in the vicinity of the reported outfalls. The receiving water was very turbid and discolored with the most prominent color a greenish-gray.

Three outfalls not reported in the applications were detected.

H-1--An active outfall was discharging from the bank of Goldsborough Creek at this location [Fig. IV-39]. The viewing angle did not allow photographing the bottom of the creek channel precluding identification of the color of the discharge.

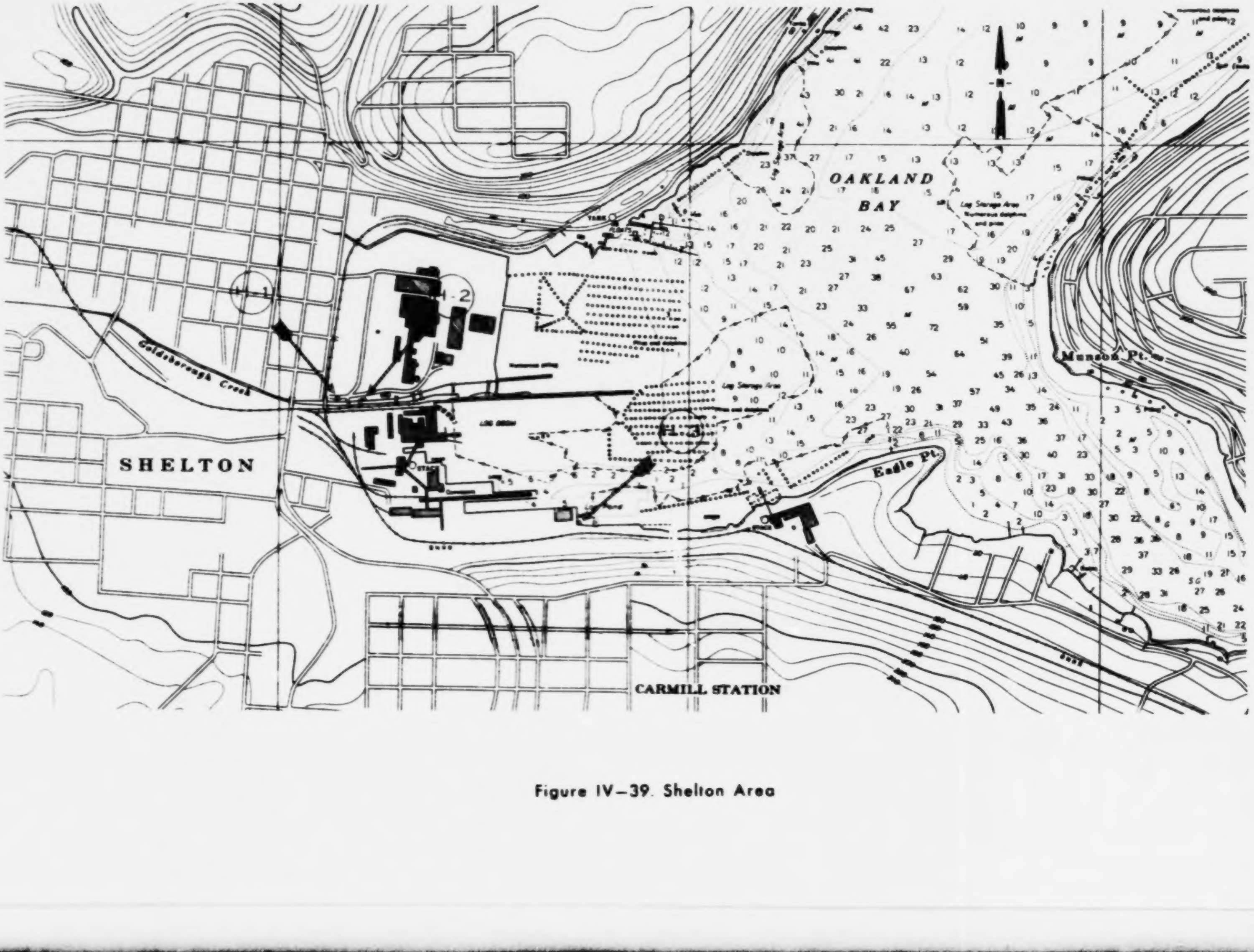

OAKLAND
BAY
SHELTON
CARMILL STATION
Goldsborough Creek
Munson Pt.
Eagle Pt.
H-1
H-2
H-3
Log Storage Area

Figure IV–39. Shelton Area

H-2--A long, large hose was coiled on the bank of Goldsborough Creek and was discharging a fluid into the creek.

H-3--An active outfall under a building was discharging with sufficient volume and flow to disturb an area of water surface 2 x 4 m (6 x 13 ft). Turbidity and discoloration in the receiving water prevented the detection of any plume associated with this discharge.

V. RESULTS OF INVESTIGATION - GRAYS HARBOR, WASH.

The upper reaches of Grays Harbor including the mouth of the Chehalis River were investigated using remote sensing techniques discussed in Section III. The purposes of the investigation were:

1. to record the presence of discharges and seeps from the ITT Rayonier Company waste lagoon on Rennie Island, and
2. to record pollution dispersion patterns and areas of influence for the lagoon discharges.

Description of Area

Grays Harbor is a shallow estuarine tributary to the Pacific Ocean west of the Seattle-Tacoma metropolitan area. The estuarine area of interest in this study is at the mouths of the Chehalis and Hoquiam Rivers adjacent to the cities of Hoquiam and Aberdeen [Fig. V-1]. Much of the upper reach of the estuary is less than 1 m (3 ft) deep and is exposed as mud flats at low-tide. The North and South Channels on opposite sides of Rennie Island convey Chehalis River outflow to the lower estuary. The Hoquiam River discharges to the North Channel. Both rivers are tidal for some distance upstream from their mouths.

Several wood products plants, seasonal seafood processing facilities, other minor industries and several municipal wastewater treatment facilities discharge effluents to Grays Harbor. This investigation was concerned only with the ITT Rayonier Company. This pulp and paper mill discharges process wastes to a lagoon on Rennie Island [Fig. V-1].

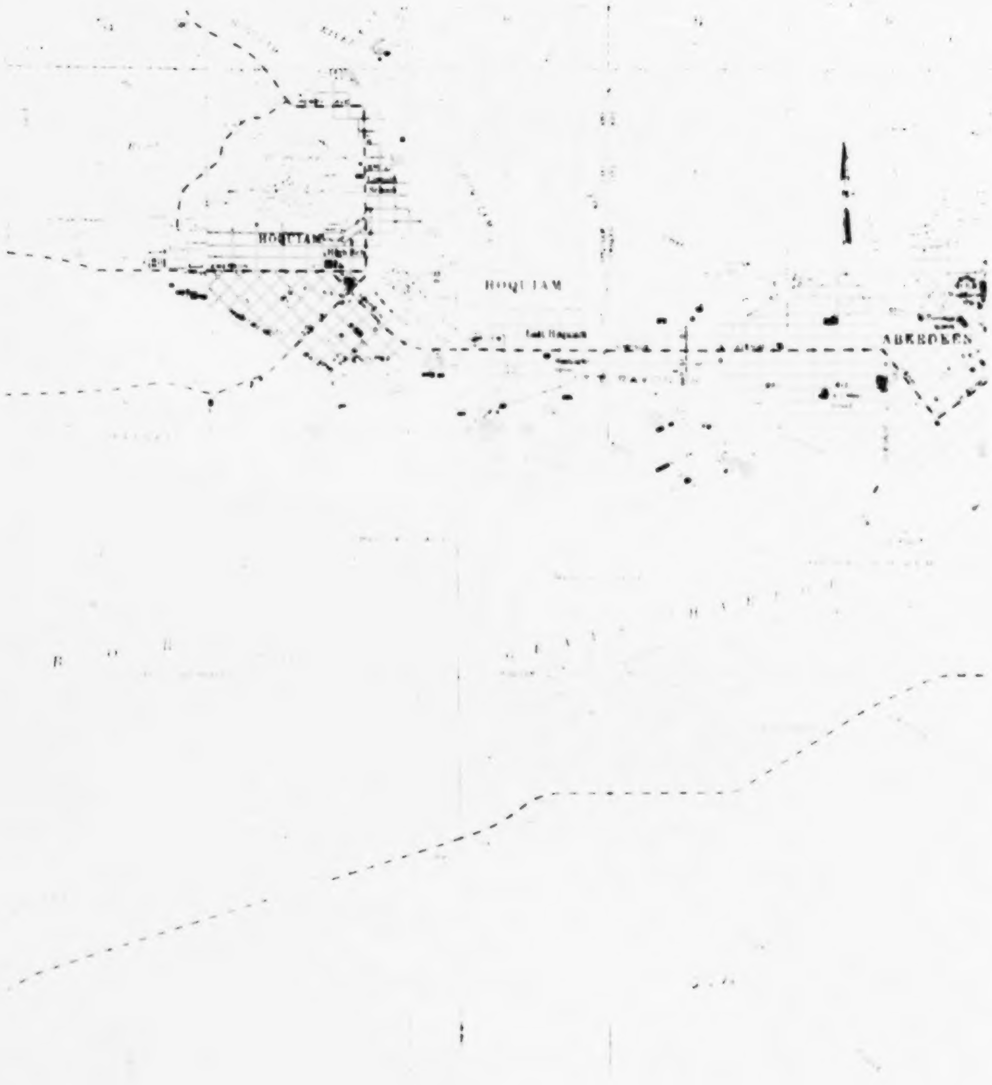

HOQUIAM
HOQUIAM
ABERDEEN

Figure V–1 Upper Grays Harbor Area

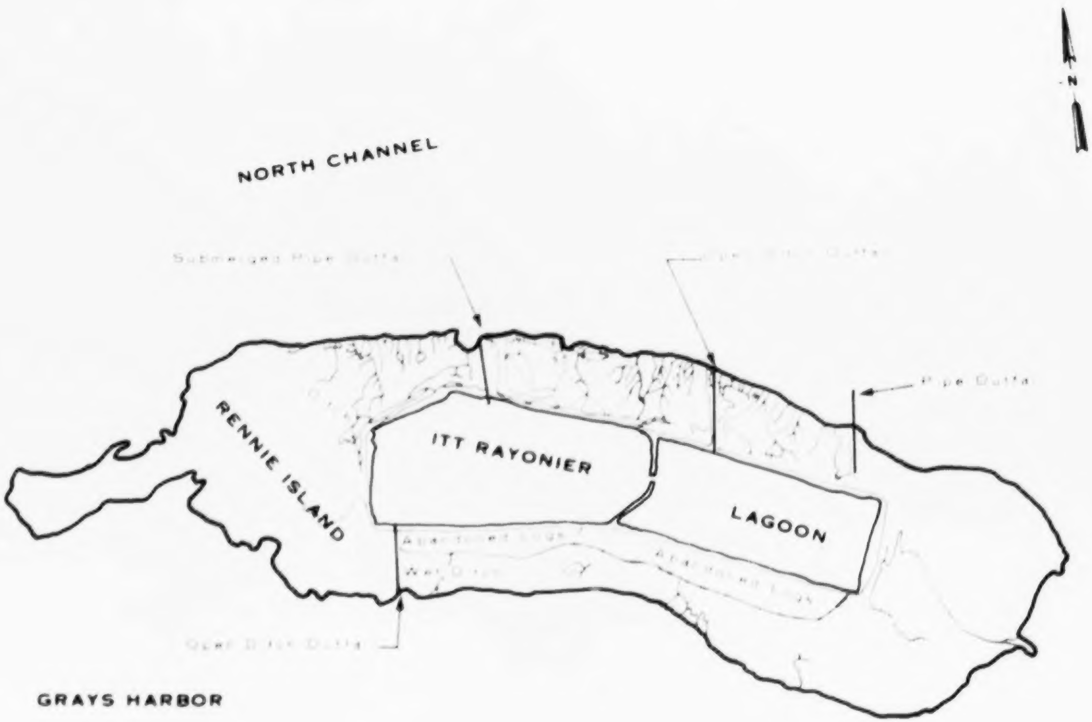

N
NORTH CHANNEL
Submerged Pipe Outfall
Open Ditch Outfall
Pipe Outfall
RENNIE ISLAND
ITT RAYONIER
LAGOON
Abandoned Dike
Wet Ditch
Abandoned Dike
Open Ditch Outfall
GRAYS HARBOR

Figure V-2. Rennie Island

These wastes are held and batch discharged twice daily on outgoing tides. The mill also has several wastewater discharges at the mill site on the north side of North Channel.

Specific Observations

A sketch of the Rennie Island lagoon [Fig. V-2] shows pipe outfalls, open ditch outfalls, and numerous seepage areas. The pipe outfalls did not appear to be active. The open ditches contained extremely dark wastewater identical in color to that in the lagoon. The seep lines sketched actually depict the near-surface movement of lagoon wastewater (indicated in the remote sensing data as a lack of or degradation of foliage and significant soil moisture and discoloration) near the lagoon dikes and open ditch movement near the island shoreline.

No significant discoloration was recorded in the upper reaches of Grays Harbor that could be attributed to the ITT Rayonier discharge.

VI. RESULTS OF INVESTIGATION
WILLAMETTE RIVER, OREG.

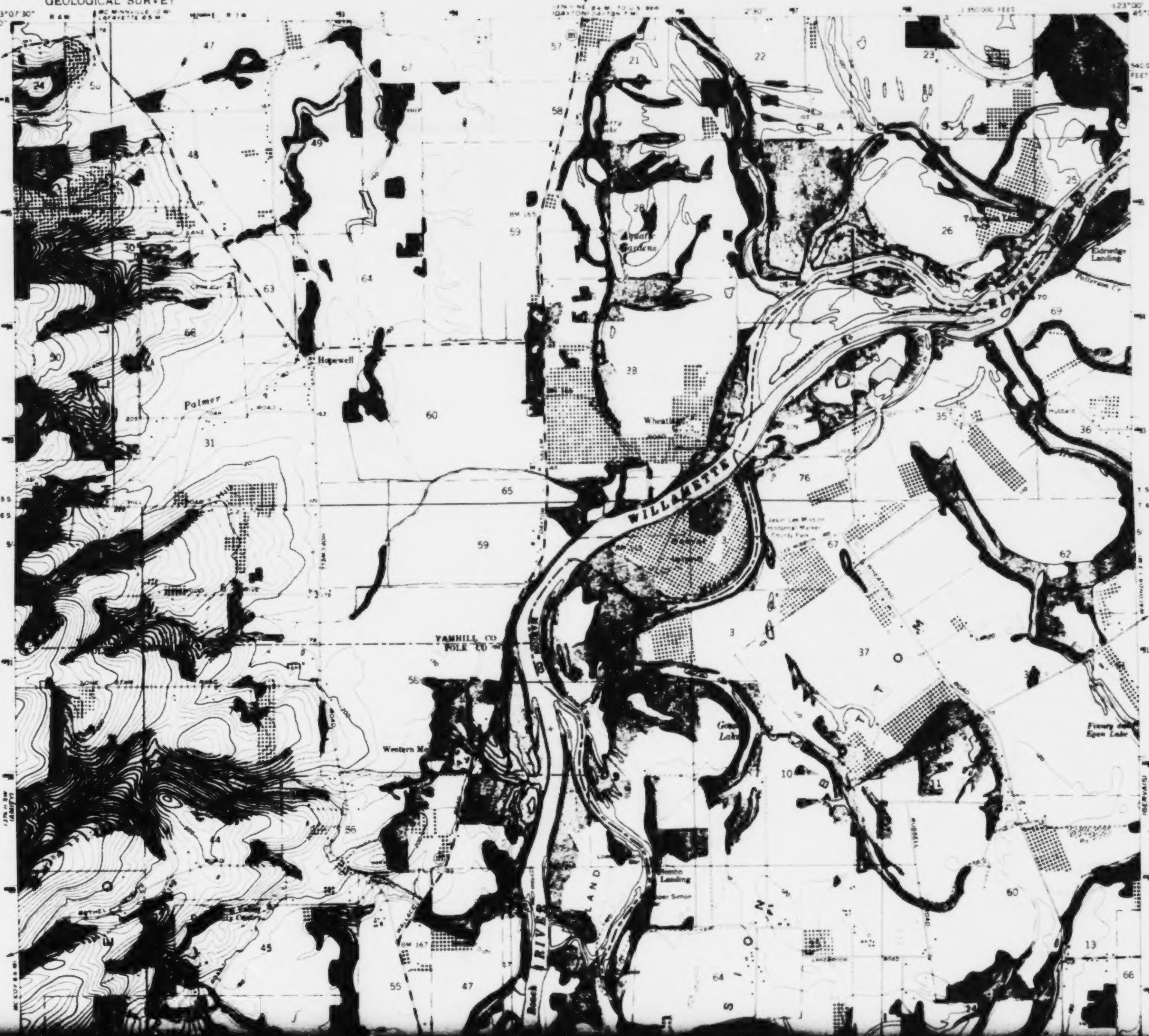
The Willamette River is in northwestern Washington. It flows north about 320 km (200 mi) from its source in the Cascade Mountains to join the Columbia River. The Willamette Valley traversed by the River for most of its length is fertile, relatively level farmland situated between the Coast Range and Cascade Mountains. A mild climate, winter rains and summer irrigation provide ideal conditions for growing a variety of crops.

Because of the agricultural nature of the Willamette Valley, non-point-sources are important contributors of pollution to the Willamette River. The area of the lower valley between Salem and Portland, a distance of about 80 km (50 mi), was investigated in late July 1973 to document the presence of non-point-sources of pollution such as irrigation return flow drainage channels. Infrared film and an Infrared Line Scanner (see Section III) were used to record the presence of surface water as an aid in detecting water flow paths.

The results of this investigation are presented on U. S. Geological Survey 7.5 minute topographical maps (original scale 1:24,000) used as base drawings with recorded surface water overprinted in red [Fig. VI-1 through VI-7]. Red lines overprinted on black-line watercourses represent a confirmation of the presence of water in those locations. Red lines alone indicate the presence of watercourses not shown on the base map. For major streams identified in black on the base map, the red overprint was omitted since these streams are known to carry perennial flow. Return flows recorded in the Oregon quandrangles of Dundee, Lake Oswego, Gladstone, and Oregon City, as well as those flows already shown on the basic maps, were insignificant.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

MISSION BOTTOM QUADRANGLE
OREGON
7.5 MINUTE SERIES (TOPOGRAPHIC)


123°07'30"
45°07'30"
123°00'
45°07'30"
WILLAMETTE
RIVER
Hopewell
Palmer
Wheatland
YAMHILL CO
POLK CO
Western
Eldriedge Landing
Lake
Landing
T 5 S
T 6 S
540 000 FEET
GRAND
MISSION
BOTTOM

110-a

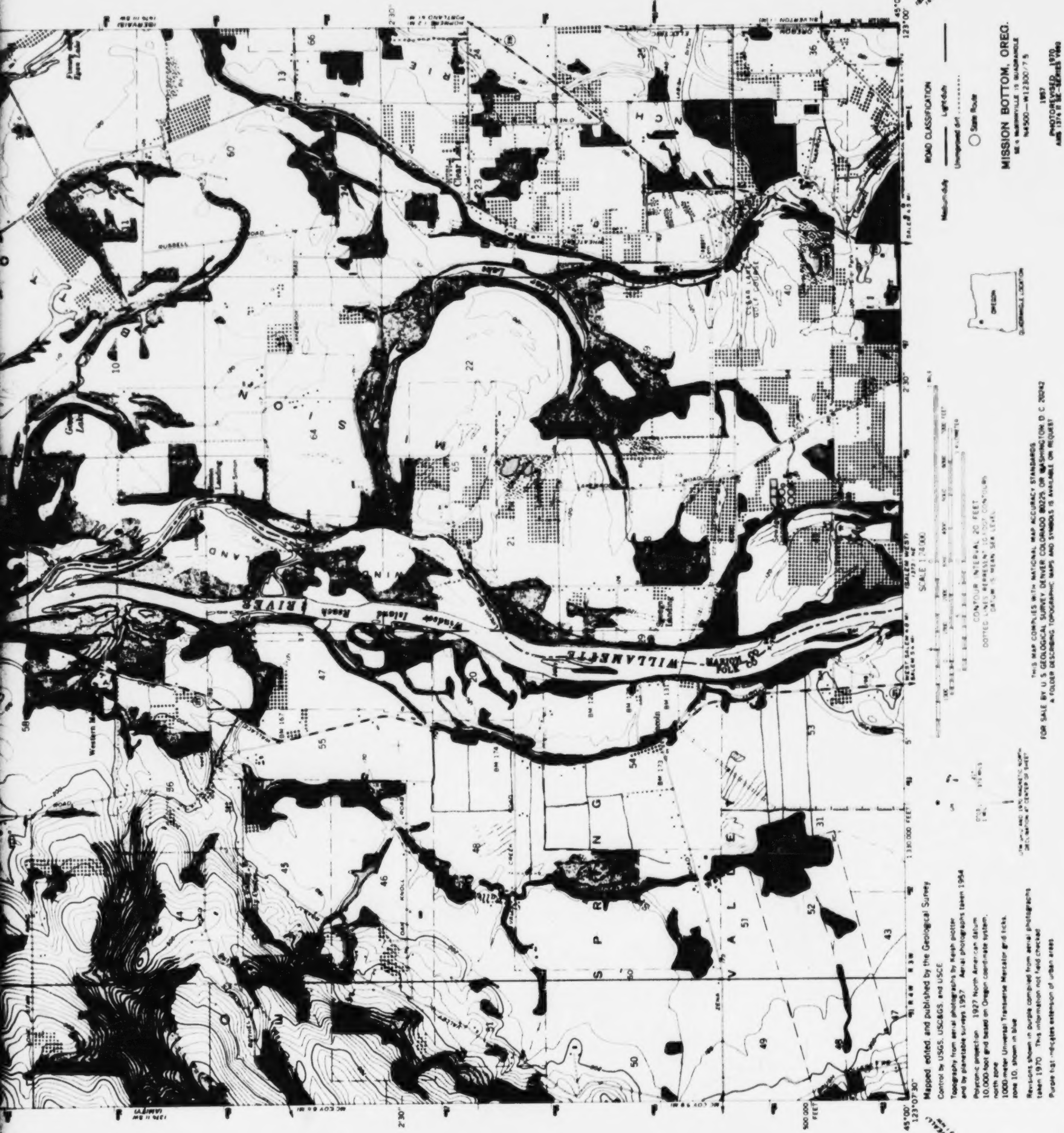

MISSION BOTTOM, OREG.
WILLAMETTE
RIVER
Windsor Island Reach
MARION CO.
POLK CO.
SCALE 1:24 000
CONTOUR INTERVAL 20 FEET
ROAD CLASSIFICATION
State Route

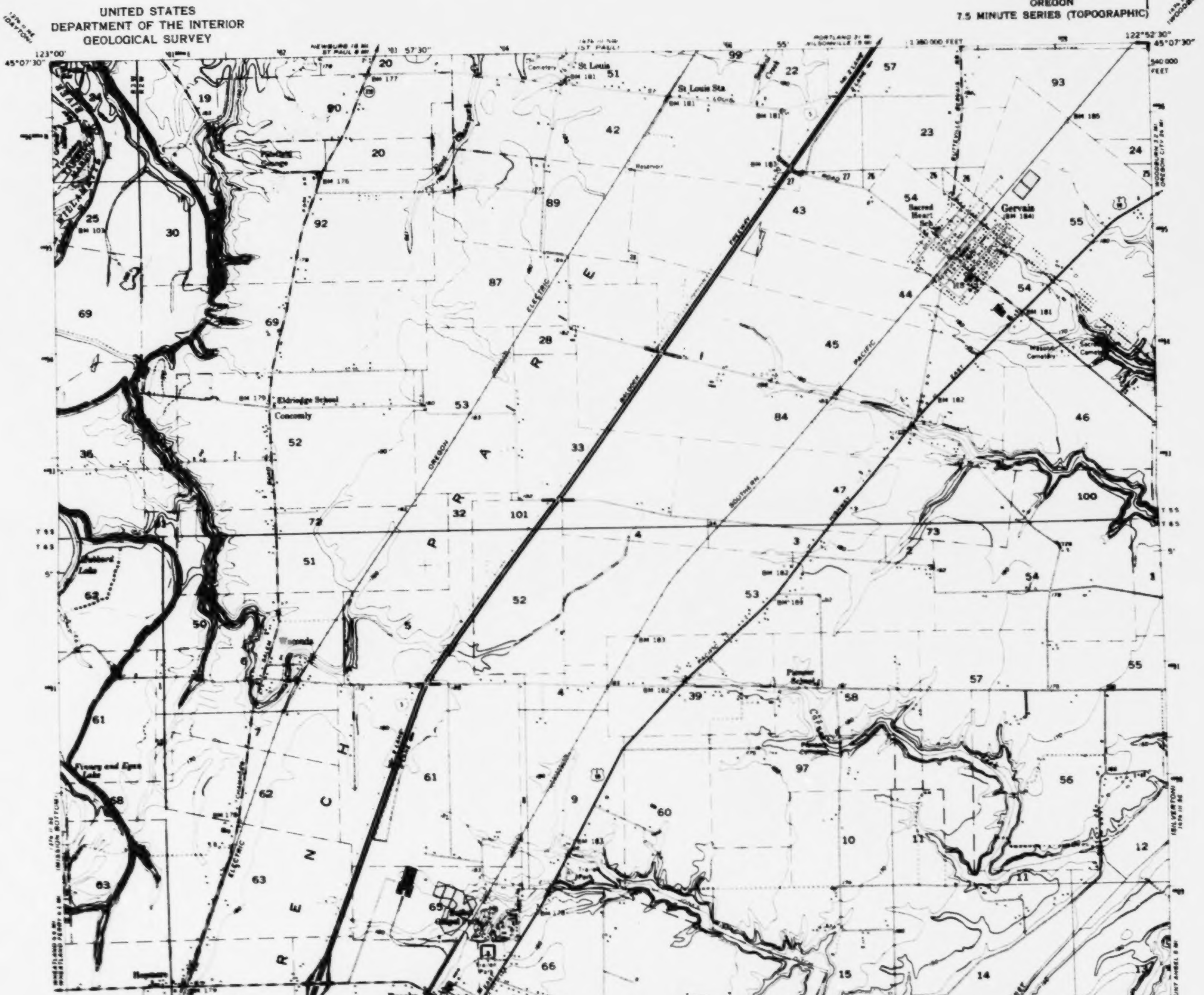
Figure VI-1. Willamette River Valley

B

A

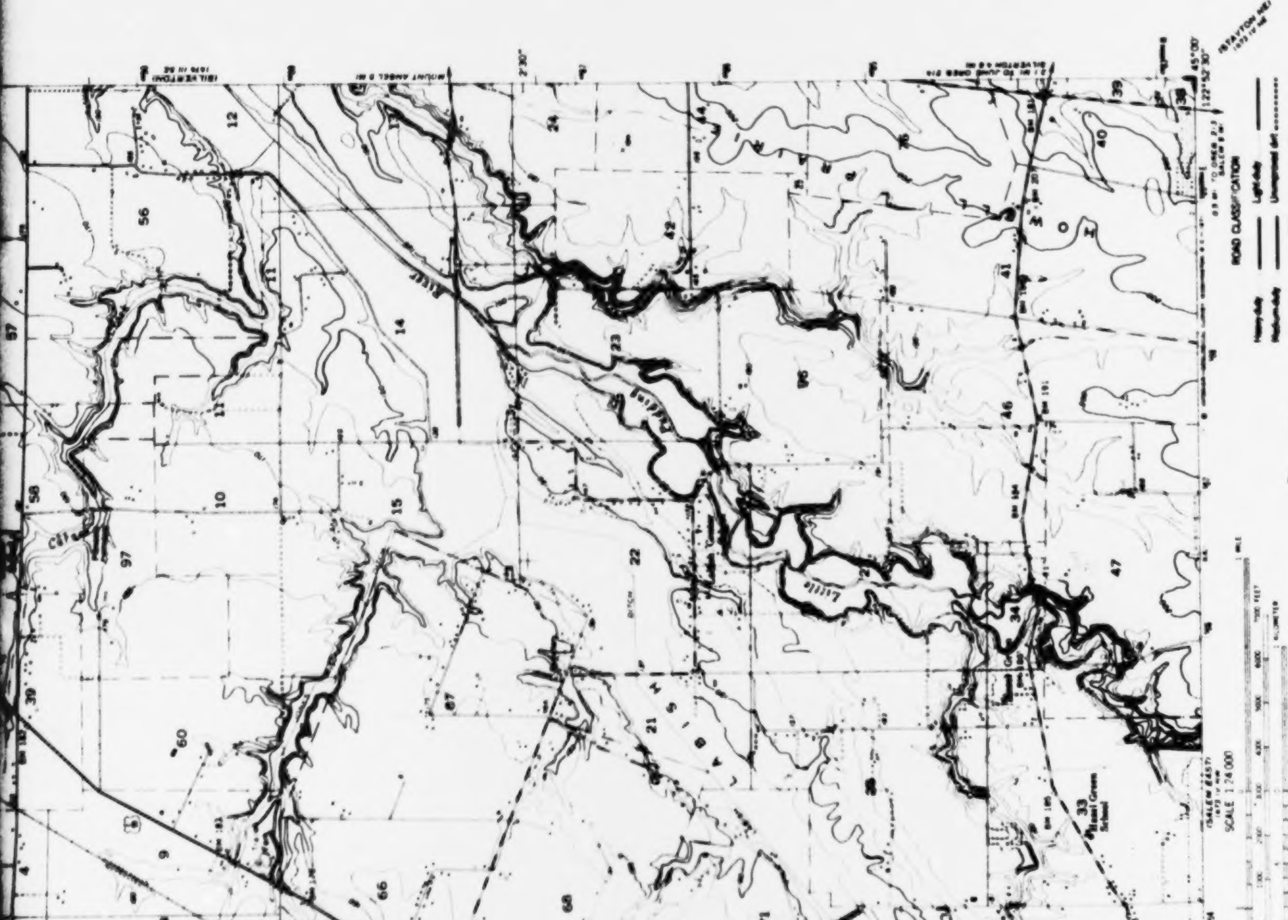
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GERVAIS QUADRANGLE
OREGON
7.5 MINUTE SERIES (TOPOGRAPHIC)



(DAYTON)
123°00'
45°07'30"
57'30"
55'
122°52'30"
45°07'30"
1 380 000 FEET
340 000 FEET
(ST PAUL)
St Louis
St Louis Sta
Cemetery
Reservoir
Gervais
Sacred Heart Sch
Eldriedge School
Concomly
Waconda
Pioneer School
Brooks
Hopmere
Hubbard Lake
Tenney and Egan Lake
WILLAMETTE
F R E N C H
P R A I R I E
ELECTRIC
OREGON
SOUTHERN
PACIFIC
T 5 S
T 6 S
5'
(SILVERTON)
(MISSION BOTTOM)

110-2



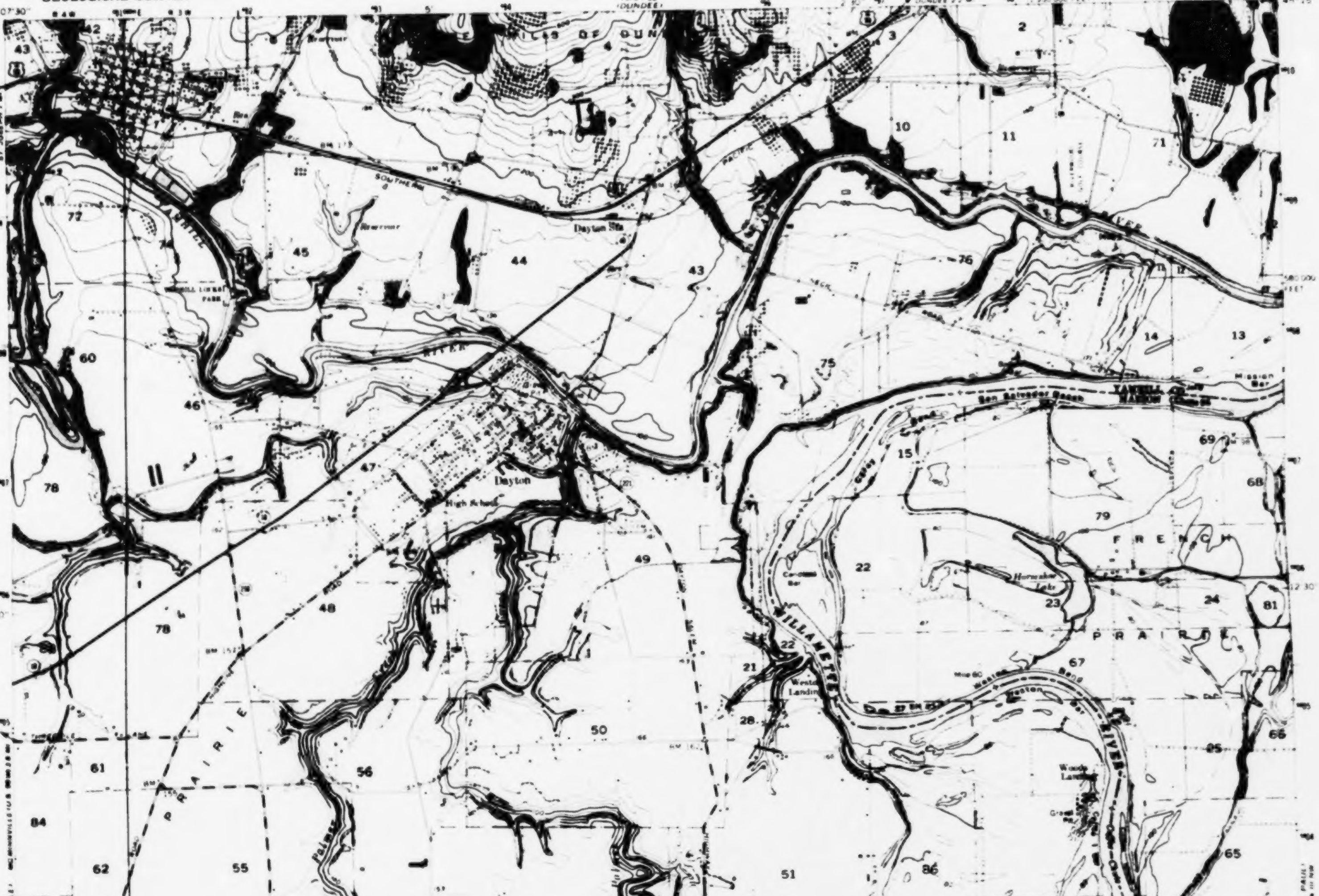
GERVAIS, OREG.
ROAD CLASSIFICATION
SCALE 1:24 000
CONTOUR INTERVAL 10 FEET
Mapped, edited and published by the Geological Survey
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D.C. 20242

Figure VI–2. Willamette River Valley

B

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DAYTON QUADRANGLE
OREGON
7.5 MINUTE SERIES (TOPOGRAPHIC)
NE ¼ MC MINNVILLE 15' QUADRANGLE


123°07'30"
45°15'
123°00'
45°15'
12'30"
Dayton
High School
Dayton Sta.
Reservoir
SOUTHERN PACIFIC
YAMHILL RIVER
WILLAMETTE RIVER
San Salvador Beach
Mission Bar
Horseshoe Lake
Weston Landing
Weston Bend
Grange Hall
Pleasantdale
FRENCH PRAIRIE
DAYTON PRAIRIE
HILLS OF DUN

110-C

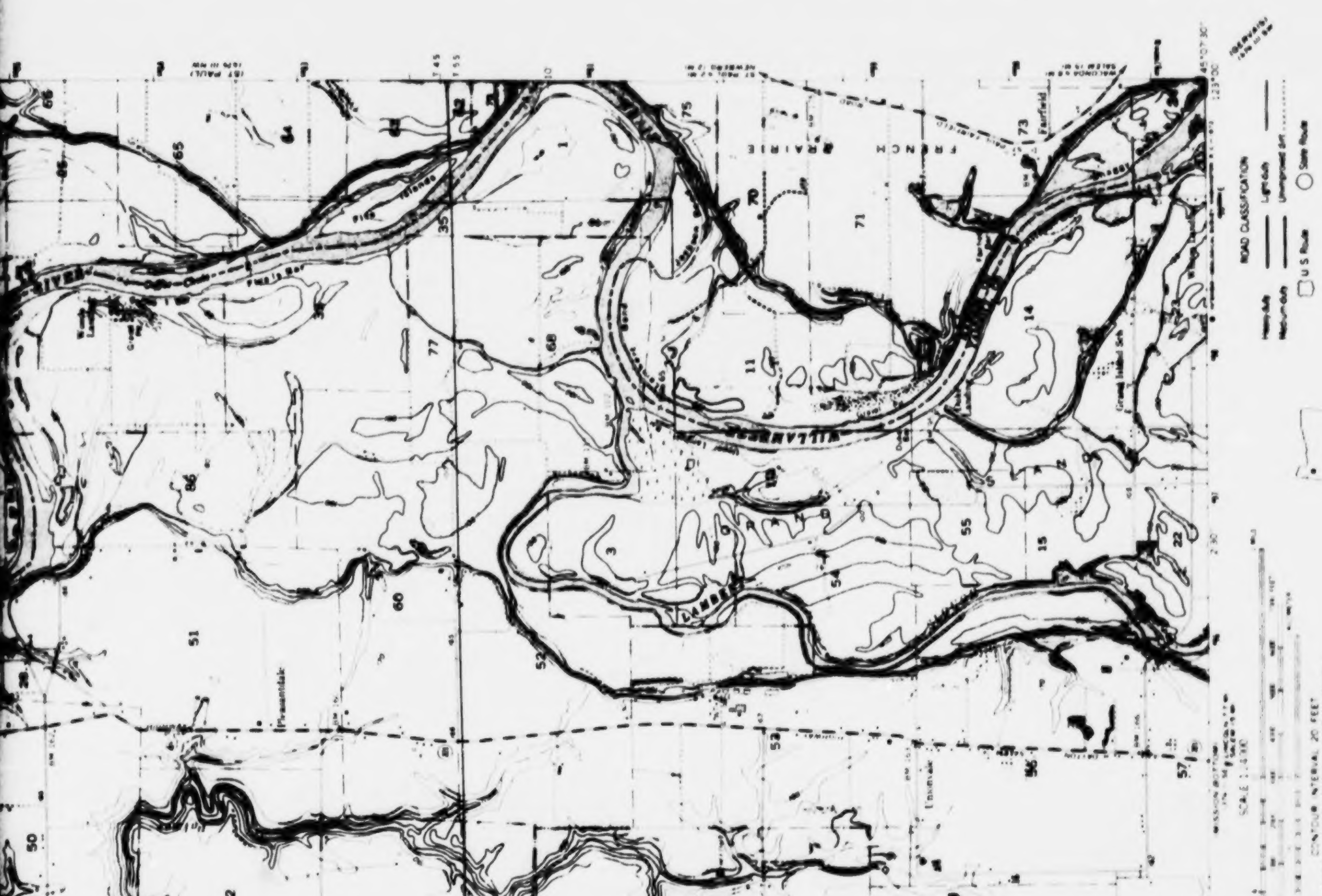

DAYTON, OREG.
ROAD CLASSIFICATION
FRENCH PRAIRIE
WILLAMETTE
SCALE 1:24000
CONTOUR INTERVAL 20 FEET

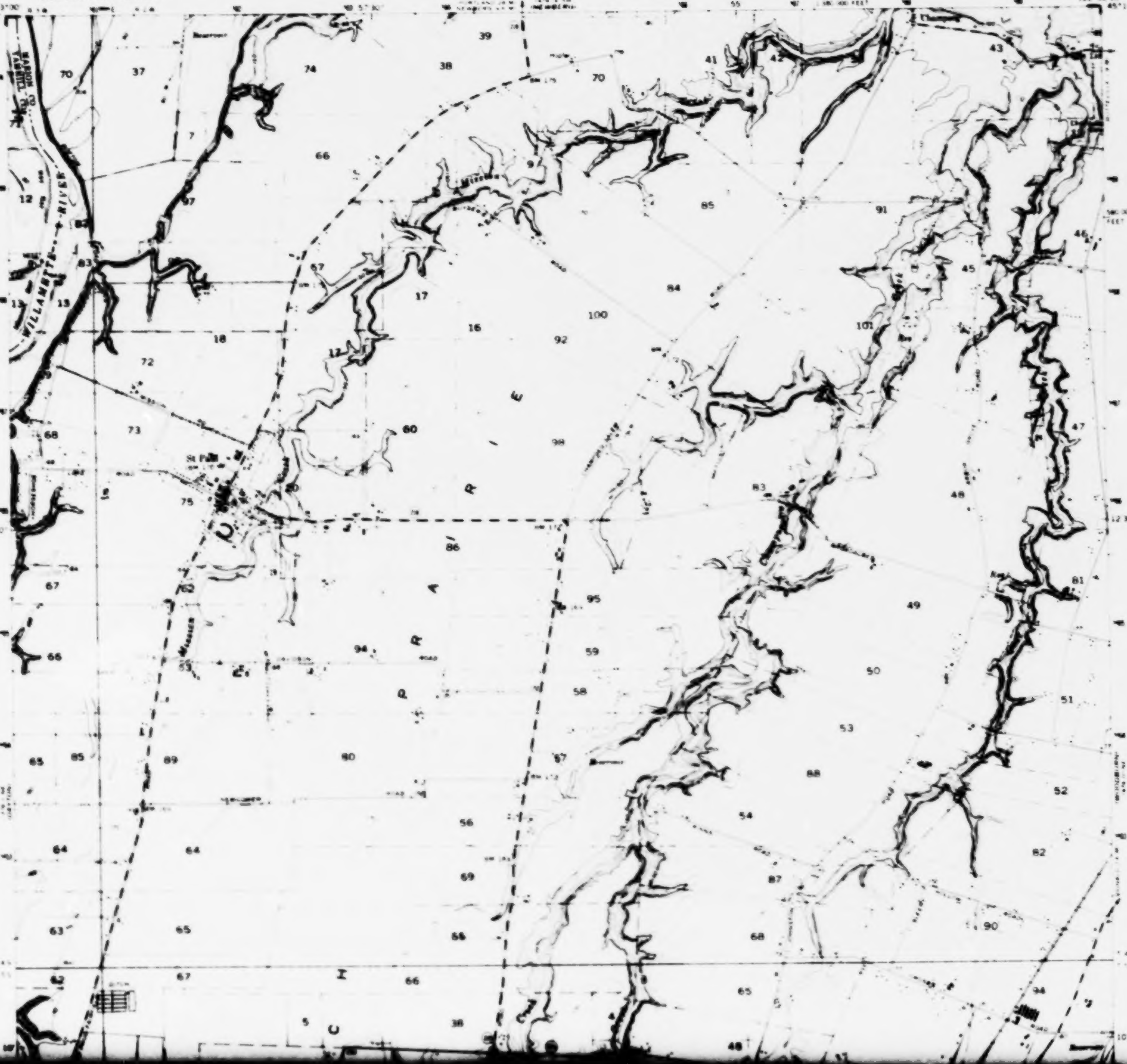
Figure VI-3. Willamette River Valley

B

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ST. PAUL QUADRANGLE
OREGON
7.5 MINUTE SERIES (TOPOGRAPHIC)

A


WILLAMETTE RIVER
MARION CO.
YAMHILL CO.
St Paul
123°00'
45°15'
122°52'30"
12'30"

110-d

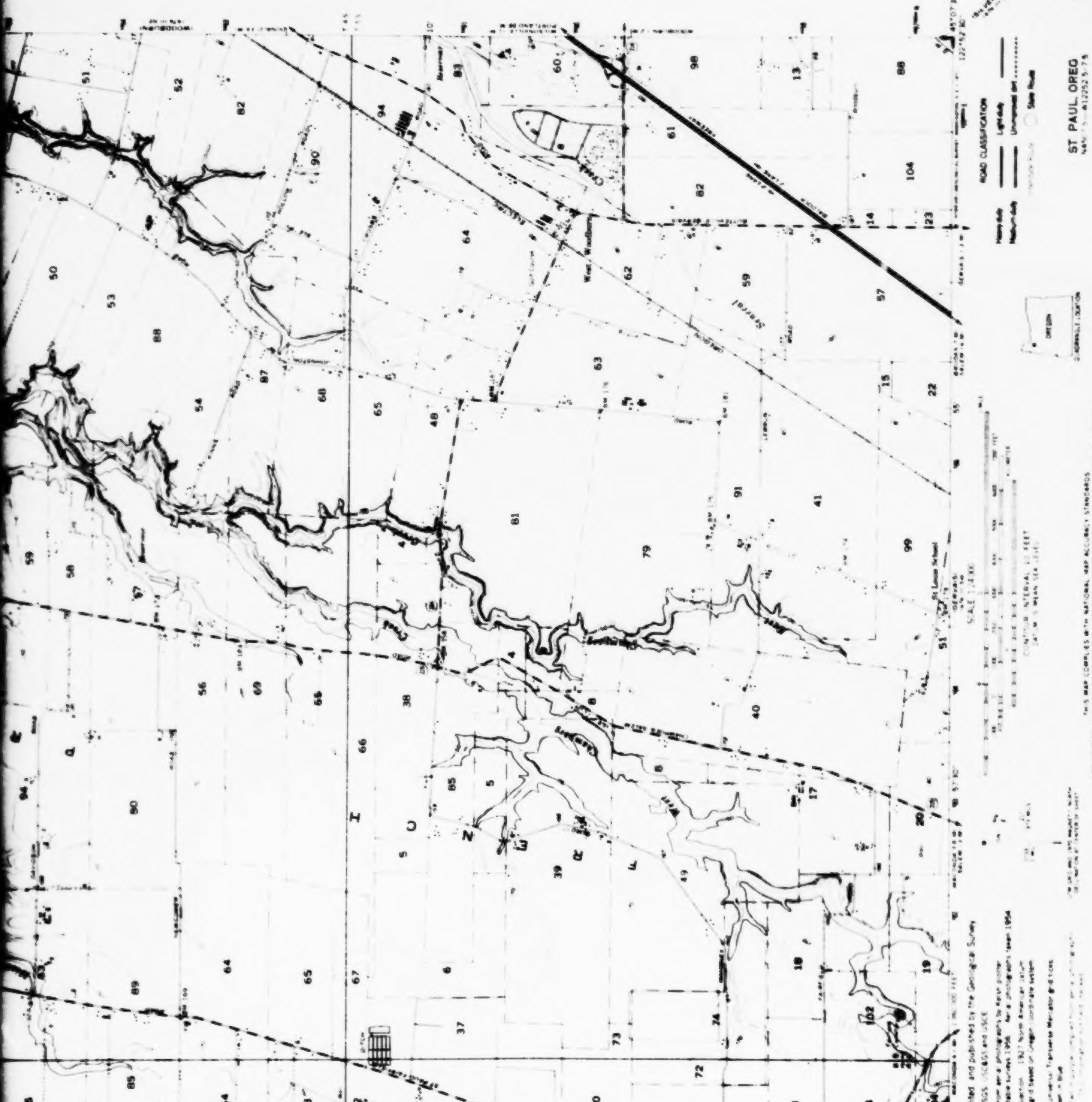
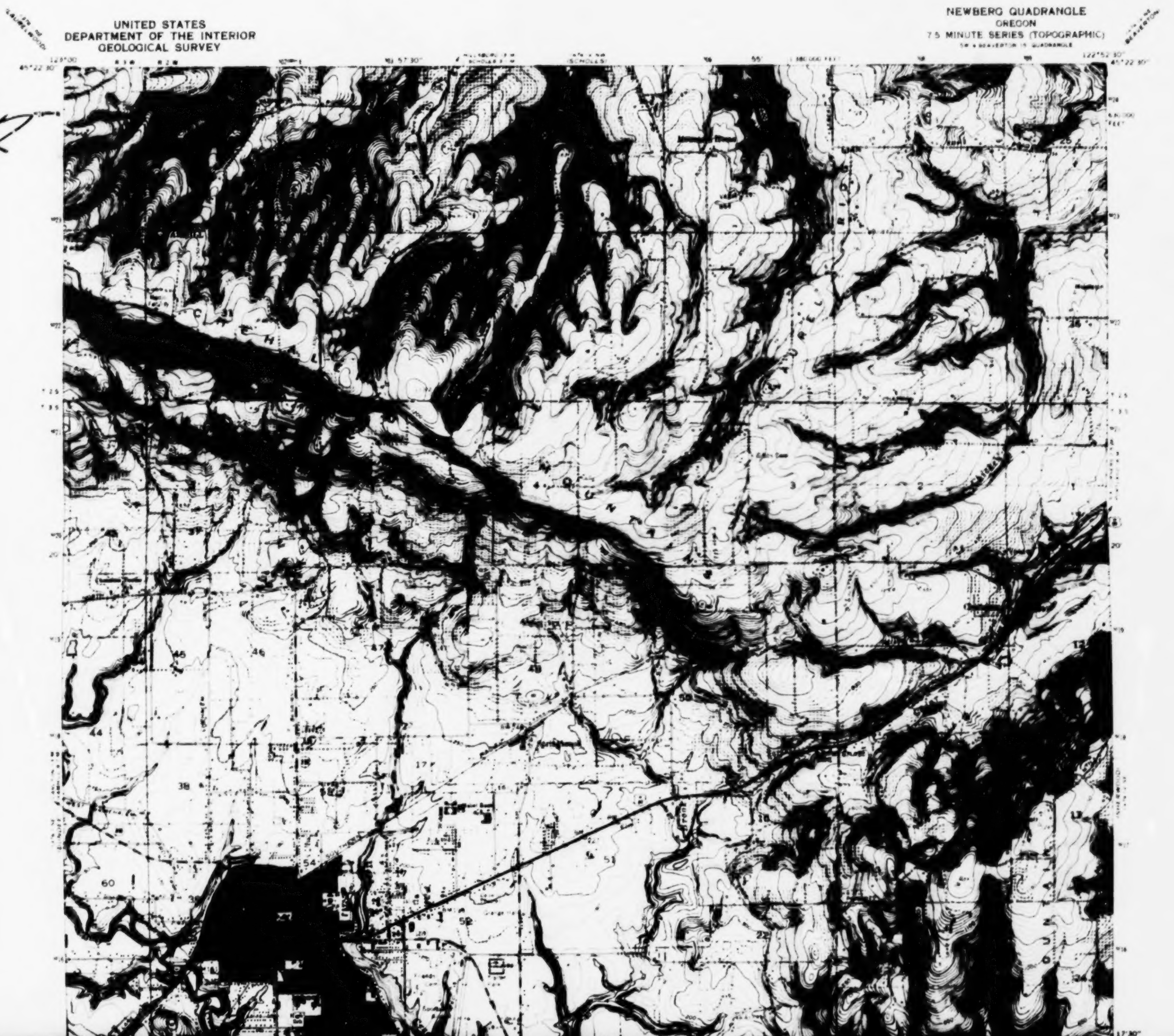

ST PAUL, OREG.
ROAD CLASSIFICATION

Figure VI-4. Willamette River Valley

B

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

NEWBERG QUADRANGLE
OREGON
7.5 MINUTE SERIES (TOPOGRAPHIC)
SW/4 BEAVERTON 15' QUADRANGLE



BEAVERTON
123°00'
45°22'30"
57'30"
55'
122°52'30"
45°22'30"
20'
17'30"

110-21

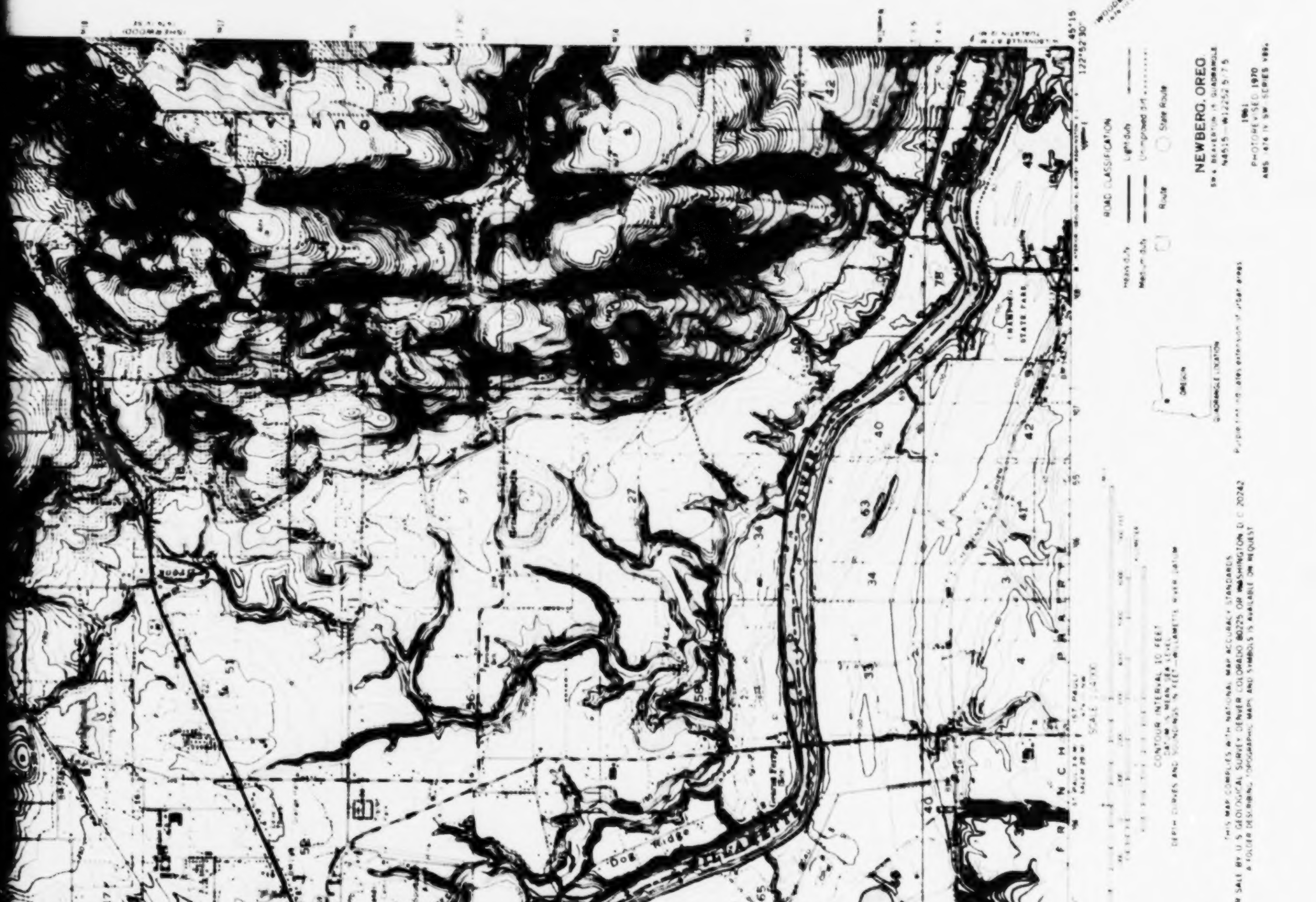
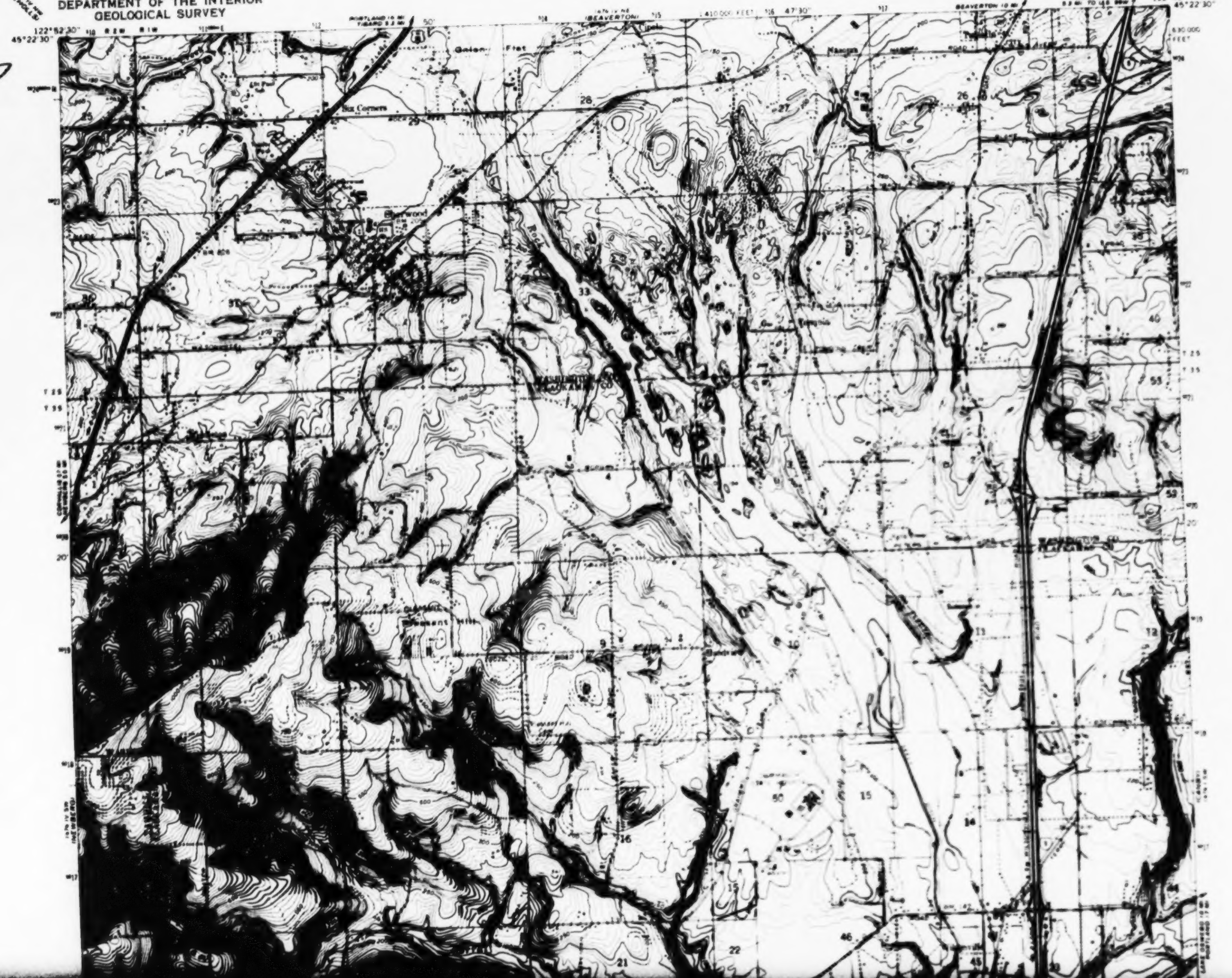

NEWBERG, OREG.
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
Route
State Route
QUADRANGLE LOCATION
OREGON
PHOTOREVISED 1970
WOODBURN
Dog Ridge
WILLAMETTE
FRENCH PRAIRIE
STATE PARK
CONTOUR INTERVAL 10 FEET
Mapped, edited, and published by the Geological Survey
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225 OR WASHINGTON, D.C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
45°15'
122°52'30"

Figure VI–5. Willamette River Valley

B

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SHERWOOD QUADRANGLE
OREGON
7.5 MINUTE SERIES (TOPOGRAPHIC)


122°52'30"
45°22'30"
122°45'
45°22'30"
47'30"
50'
20'
1 410 000 FEET
(BEAVERTON)
Six Corners
Rock
T 2 S
T 3 S
26
27
28
29
33
4
9
10
13
15
16
21
22

110-8

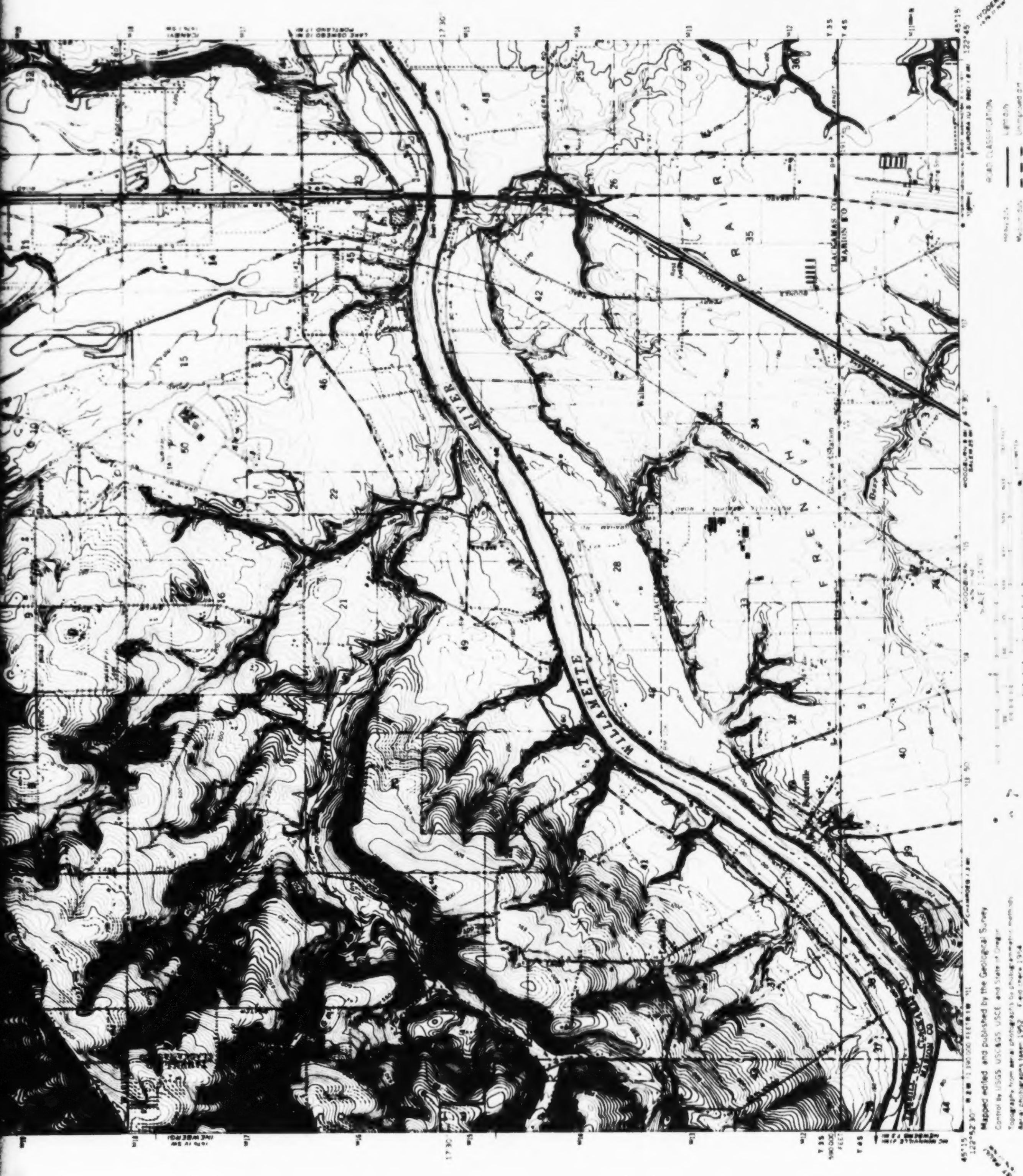
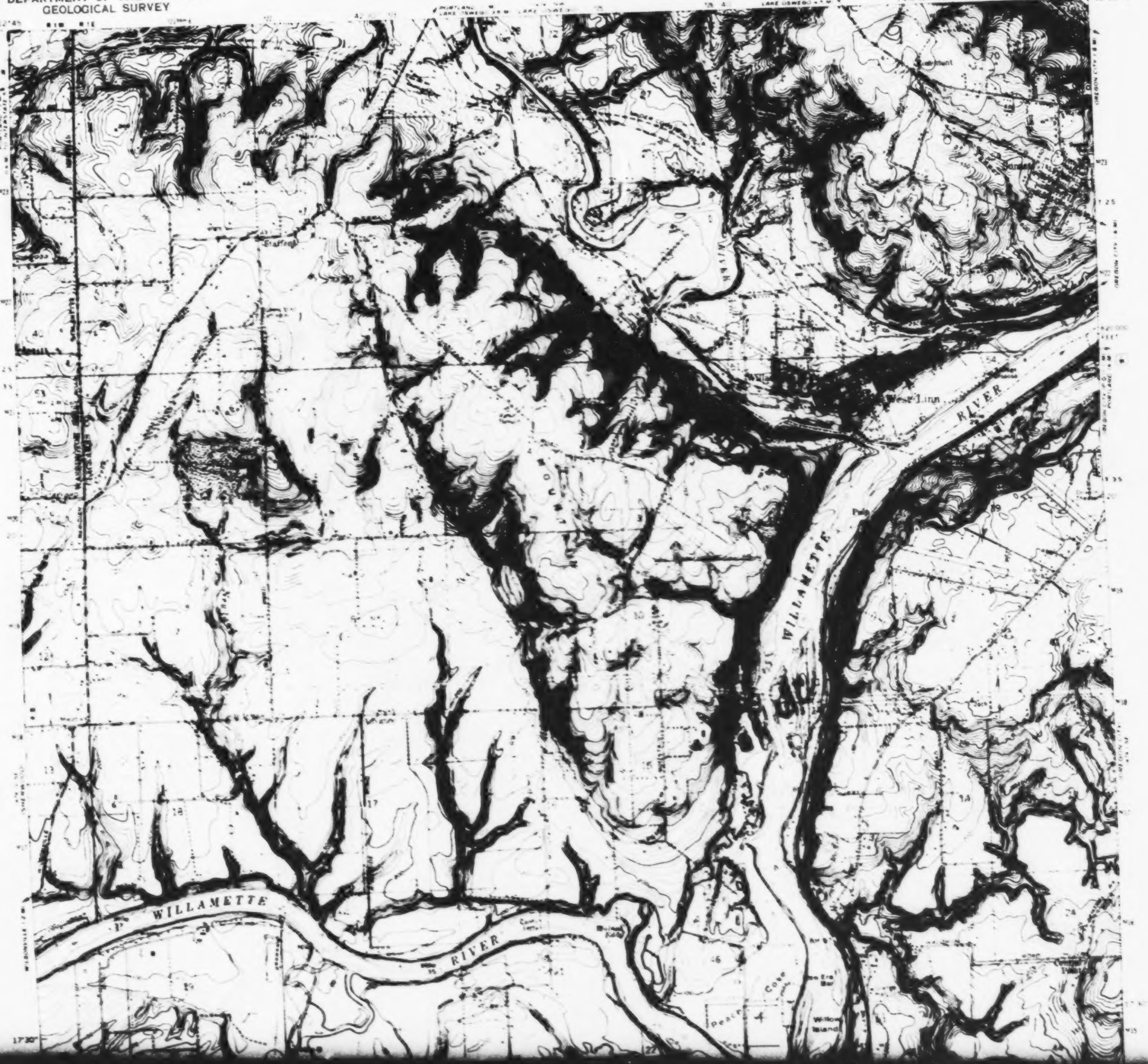

WILLAMETTE RIVER
FRENCH PRAIRIE
SHERWOOD, OREG.
CONTOUR INTERVAL 10 FEET
FOR SALE BY U S GEOLOGICAL SURVEY DENVER COLORADO 80225 OR WASHINGTON D C 20242
Mapped, edited, and published by the Geological Survey

Figure VI–6. Willamette River Valley

B

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CANBY QUADRANGLE
OREGON
7.5 MINUTE SERIES (TOPOGRAPHIC)
SW 4 OREGON CITY 15' QUADRANGLE


122°37'30"
45°22'30"
LAKE OSWEGO
West Linn
WILLAMETTE
RIVER
WILLAMETTE
RIVER
Peach Cove
Willow Island
17'30"

110-g

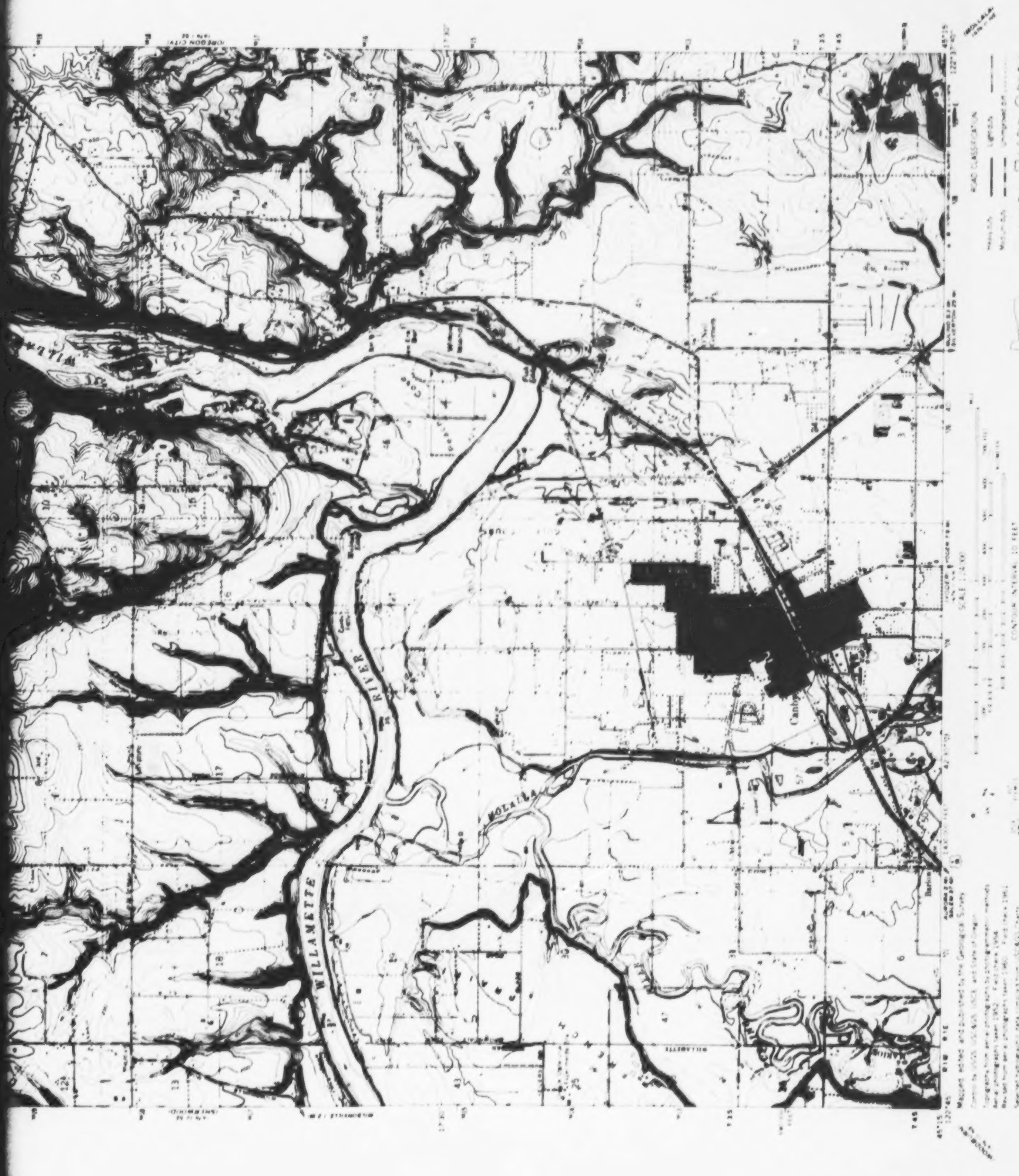

CANBY, OREG.
WILLAMETTE
RIVER
MOLALLA
FOR SALE BY U S GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D C 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
ROAD CLASSIFICATION
CONTOUR INTERVAL 10 FEET

Figure VI–7. Willamette River Valley

B

VII. RESULTS OF INVESTIGATION
COEUR D'ALENE LAKE, IDAHO

Coeur D'Alene Lake is in the panhandle region of northern Idaho just east of Spokane, Wash. Fed by the Coeur D'Alene and St. Joe Rivers and numerous creeks, the lake is the source of the Spokane River. A popular recreation area, the lake is surrounded by partially timbered foothills and semi-mountainous terrain.

The lake was investigated on 26 July 1973 to define the presence of algae and other aquatic plant life. Infrared film that records the presence of chlorophyll was the sensor used [see Section III].

Observed locations of significant areas of aquatic plant growth are printed in red on a U. S. Geological Survey topographical map of the lake [Fig. VII-1]. In general, no algae were detected in the main body of the lake. However, numerous patches of aquatic plant growth that may have contained algae were recorded in the lake's backwaters and bays. (The sensor used does not distinguish between algae and aquatic plants.) With the exception of an area immediately to the north of the mouth of the Coeur D'Alene River, the patches were small. In the large area the aquatic plant growth was widespread along shore and in the water. One area of growth was recorded on both sides of the U. S. Highway 95 bridge near the outlet to the Spokane River.

COEUR D'ALENE LAKE
Wolf Lodge Bay
Cougar Bay
Mica Bay
Carlin Bay
L A K E
D'A L E N E
SPOKANE
RIVER

A

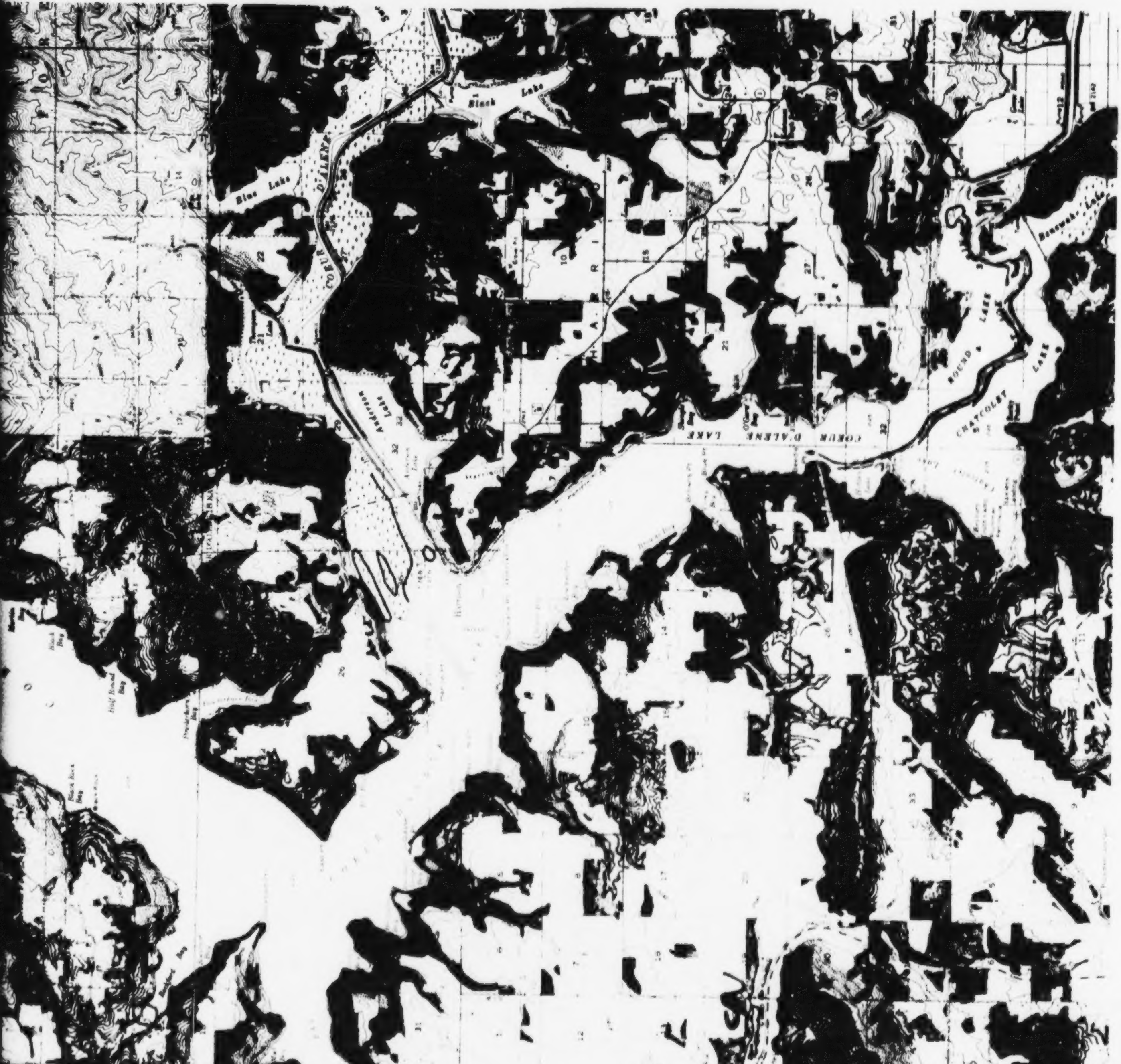

Blue Lake
Black Lake
COEUR D'ALENE
Anderson Lake
COEUR D'ALENE LAKE
ROUND LAKE
CHATCOLET LAKE
Benewah Lake

Figure VII–1. Coeur D' Alene Lake

B

VIII. RESULTS OF INVESTIGATION
SNAKE AND SALMON RIVERS, IDAHO

For much of its length the Snake River traverses fertile irrigated farm land. Several tributaries including the Boise and Payette Rivers also flow through intensely farmed irrigated valleys. Much of this farmland produces feed crops which are then used to feed livestock, primarily cattle. Animal feedlots are numerous in the Snake River area and are important sources of pollutants to the river system where they are located in close proximity to watercourses or drainage canals.

Two segments of the Snake River valley, the lower Payette River valley and the Boise River valley from Boise to the Snake River, were investigated in late April 1973 to document the presence of feedlots. The locations of these areas and flight paths are shown in Figures VIII-1, VIII-2 and VIII-3. The areas were imaged from an altitude of 5,500 m (18,000 ft) above ground level providing coverage of a band 6,100 m (20,000 ft) wide parallelling the flight path.

Several hundred feedlots of varying sizes were located in these areas. The location of each feedlot was indicated on the 23 cm (9 in.) wide film obtained from the study and the film transmitted to EPA Region X for their use in preparing a feedlot inventory. The locations of feedlots are not documented in this report.

A similar investigation of the narrow Salmon River valley in north-central Idaho was conducted in late July 1973. The middle reach of the river covered extends about 160 km (100 mi) upstream from Riggins to near North Fork. No feedlots were detected in this area.

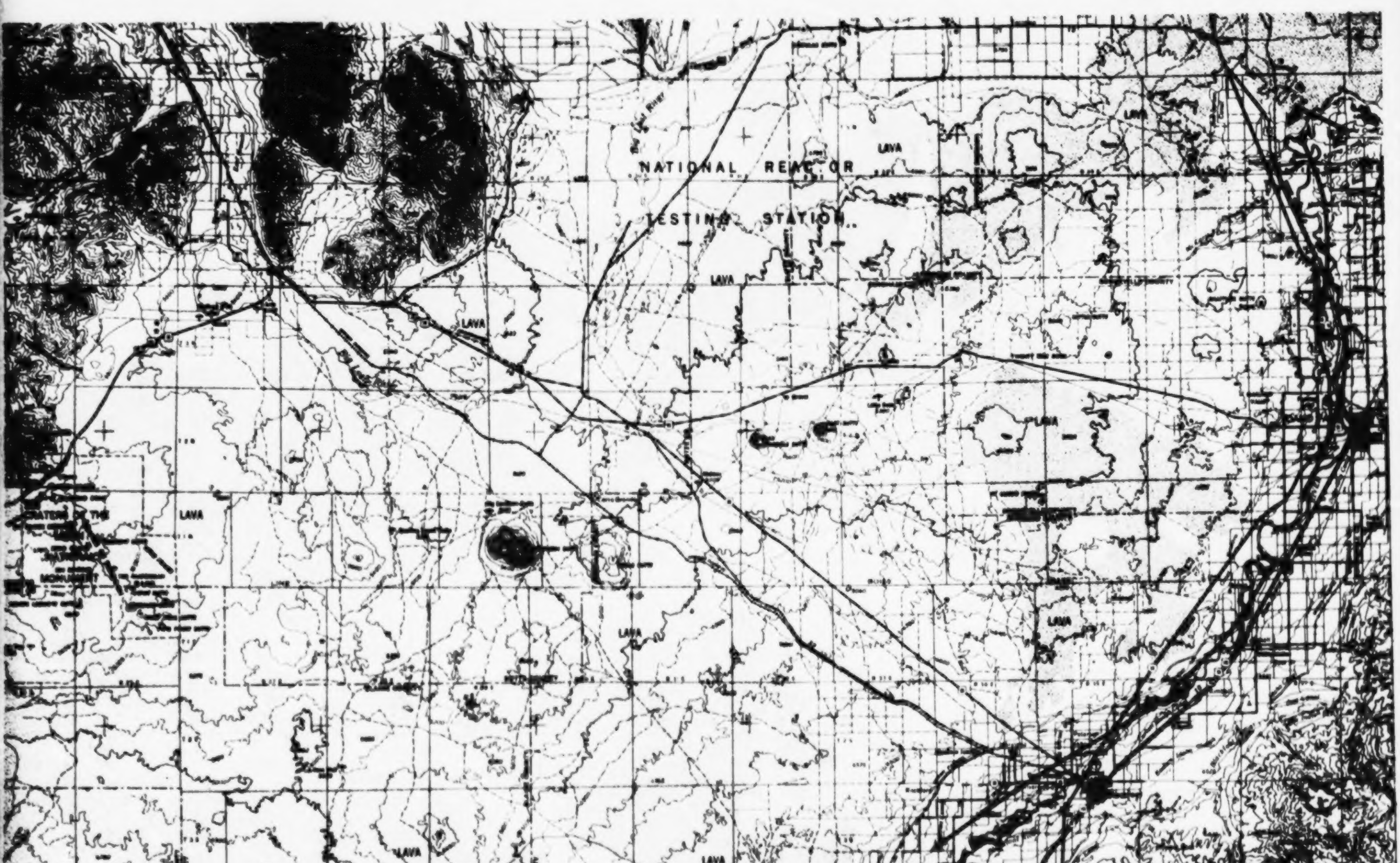
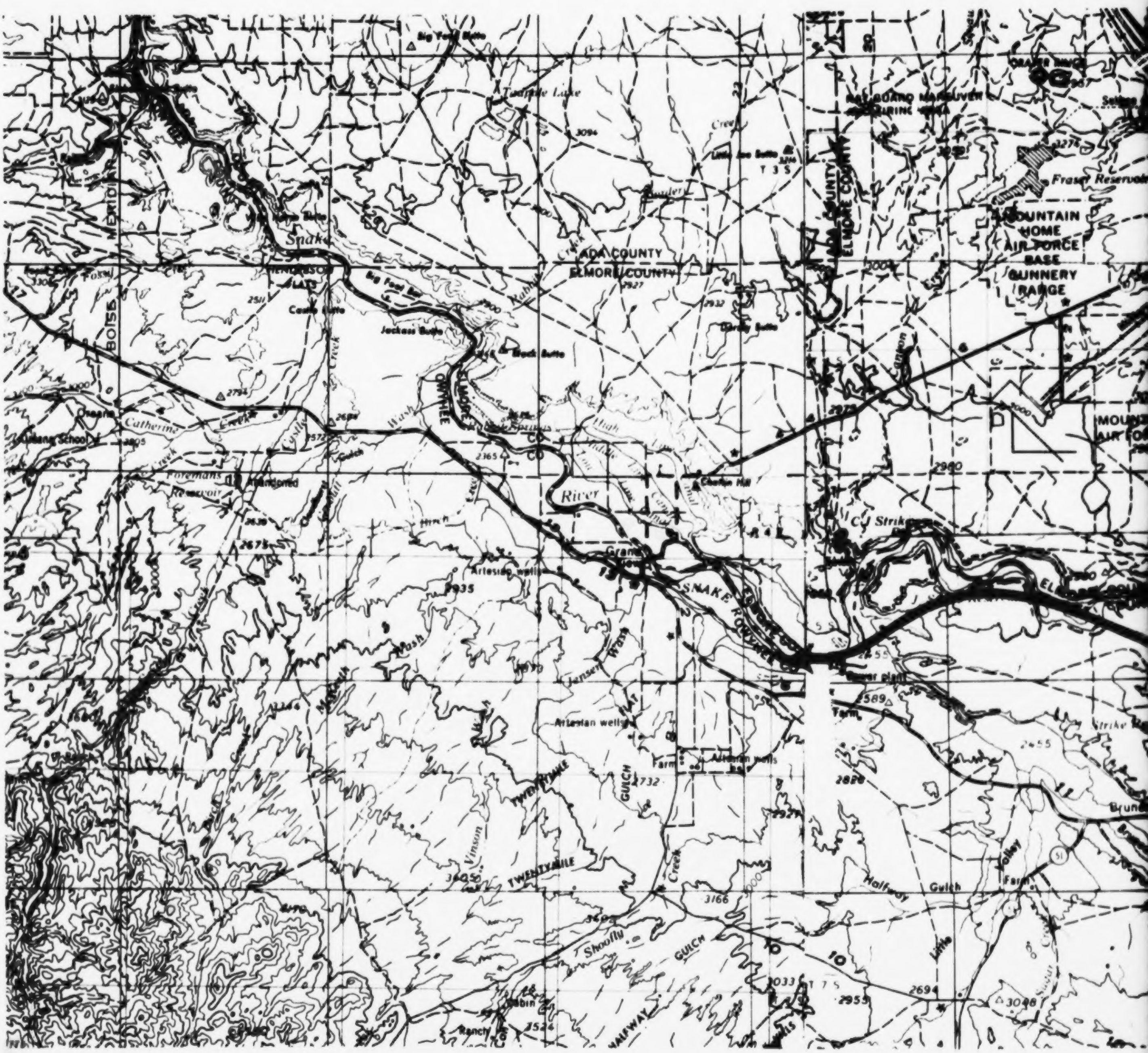

NATIONAL REACTOR
TESTING STATION
LAVA
LAVA
LAVA
LAVA
LAVA
LAVA
LAVA
LAVA
RESERVOIR
FORT HALL INDIAN

Figure VIII–1. Idaho Falls – American Falls



Big Foot Butte
Teapot Lake
Little Joe Butte
T 3 S
NATIONAL GUARD MANEUVER AND FIRING AREA
ADA COUNTY
ELMORE COUNTY
Fraser Reservoir
MOUNTAIN HOME AIR FORCE BASE GUNNERY RANGE
BOISE MERIDIAN
Snake
HENDERSON FLATS
Big Foot Bar
Castle Butte
Jackass Butte
Black Butte
Dorsey Butte
OWYHEE
Catherine Creek
Foremans Reservoir
Abandoned
Wash
River
Coyote Hill
C J Strike
MOUNTAIN HOME AIR FORCE
Artesian wells
SNAKE RIVER
Grand View
Jansen Wash
Artesian wells
Farm
Artesian wells
TWENTYMILE
GULCH
Vinson Wash
TWENTYMILE
Creek
Halfway Gulch
Shoofly
GULCH
HALFWAY
Cabin
Ranch
Bruneau
Strike
2735
2794
2805
2689
2572
2365
2675
2639
2935
3094
2927
2932
2972
2980
2732
2927
2589
2455
2880
3605
3166
3033
2955
2694
3048
3526
10

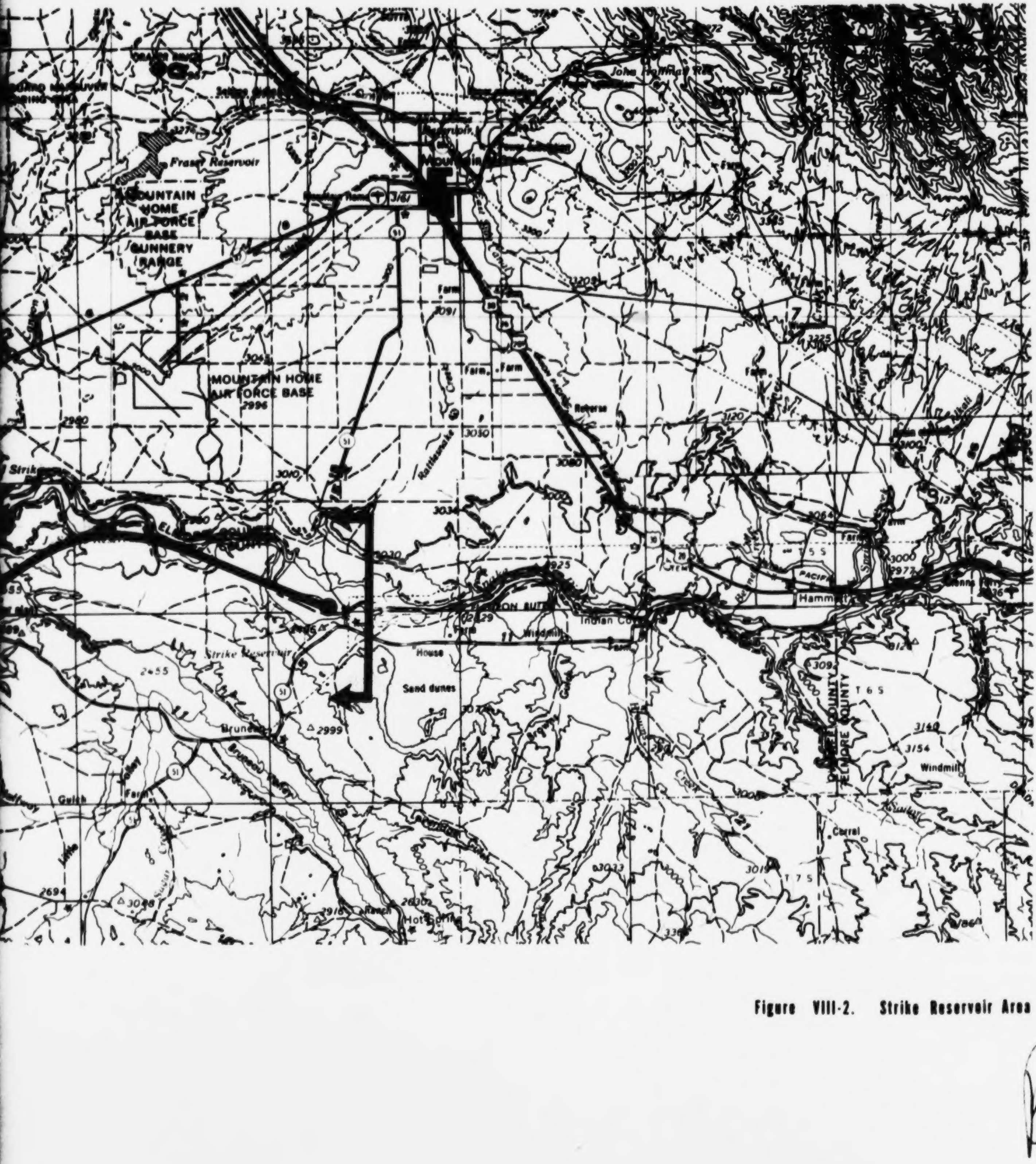
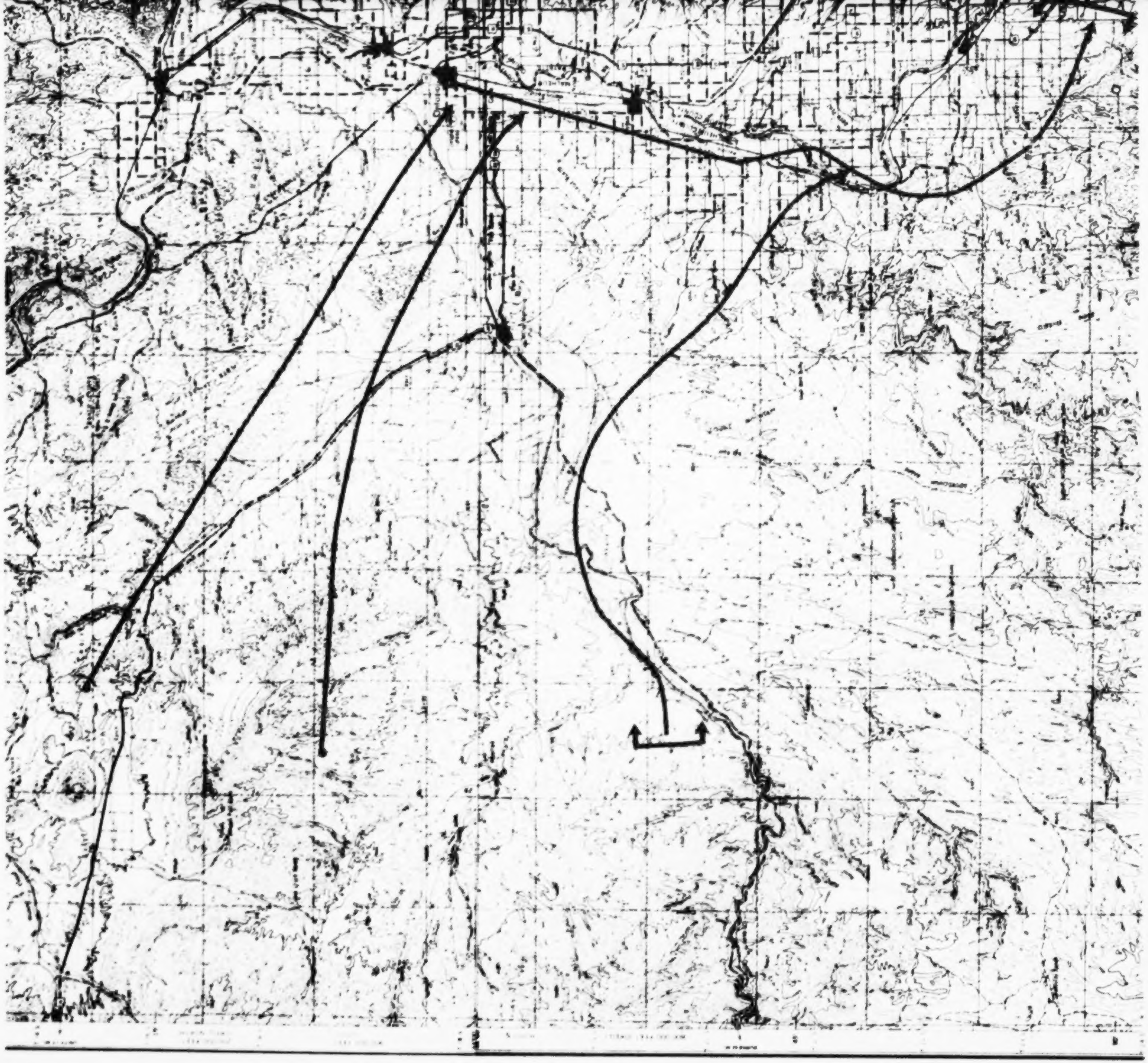

Fraser Reservoir
MOUNTAIN HOME AIR FORCE BASE GUNNERY RANGE
Mountain Home
MOUNTAIN HOME AIR FORCE BASE
2996
2960
3181
3091
3030
3010
3034
3080
3120
3064
Farm
Reverse
Rattlesnake
Strike
Strike Reservoir
2455
House
Sand dunes
Indian Cove
Windmill
Hammett
PACIFIC
Bruneau
Gulch
2999
3038
2694
2916
Ranch
Hot Spring
Corral
3019
3033
T 5 S
T 6 S
T 7 S
OWYHEE COUNTY
ELMORE COUNTY
3140
3154
2925
2972
3000
3225
3585
51
30

Figure VIII-2. Strike Reservoir Area

B



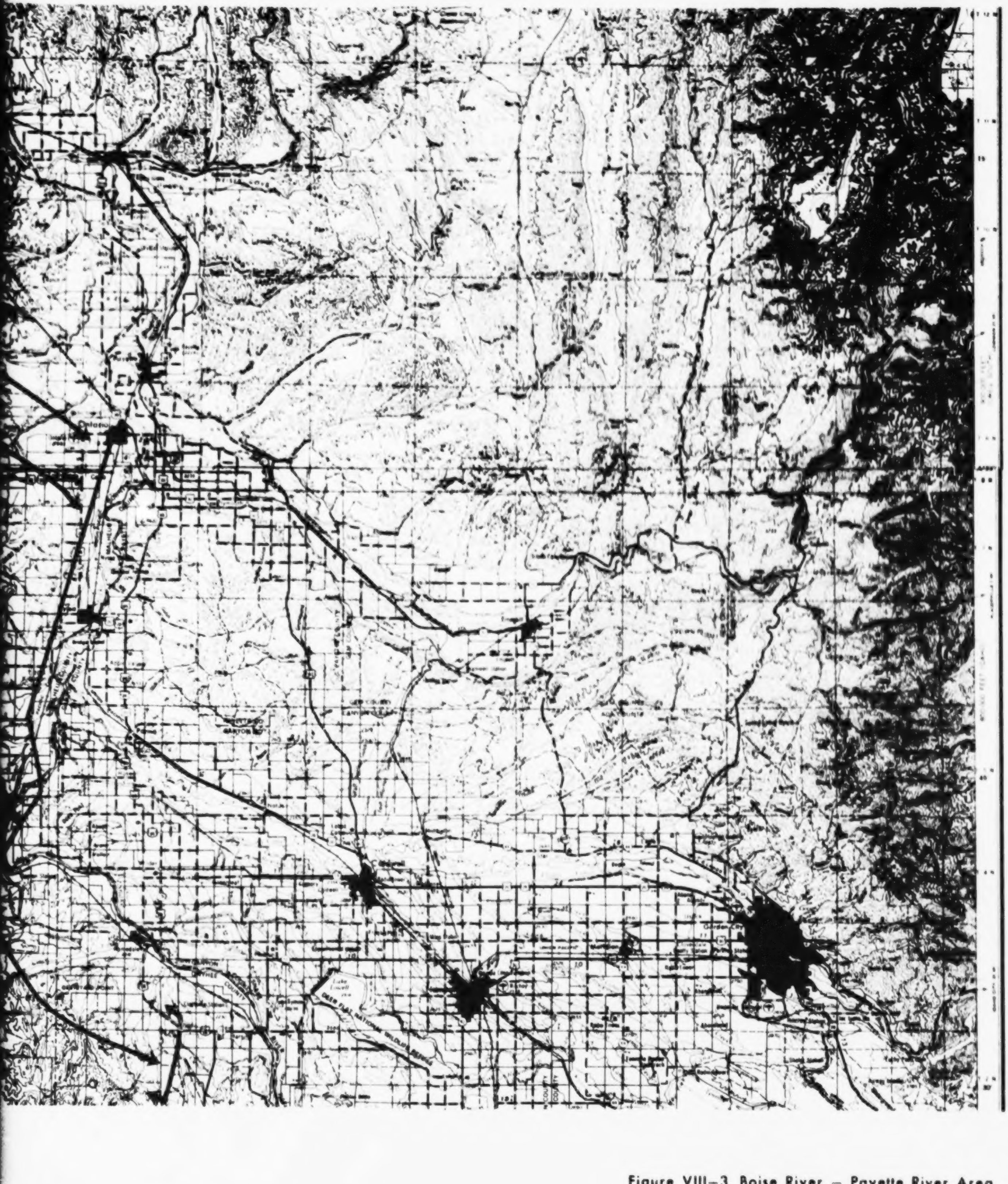


Figure VIII-3. Boise River – Payette River Area

B

APPENDIX A

FILM SPECTRAL SENSITIVITY DATA

OPTICAL FILTER TRANSMITTANCE DATA

The spectral curves for each film and optical filter used during this reconnaissance program are provided on the following pages:

i) SO-397 with HF3/HF5 filter combination

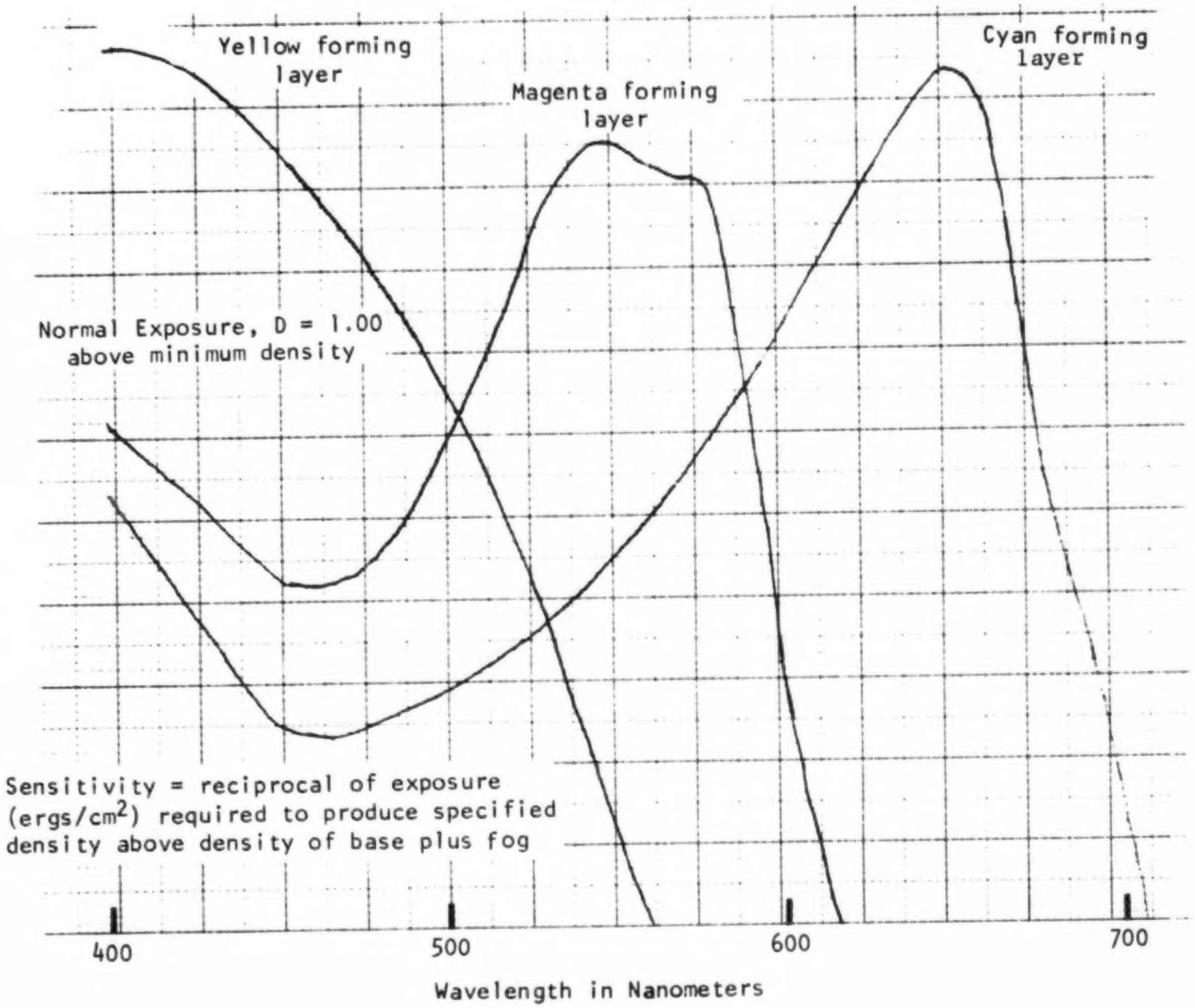
ii) 2403 with 47A

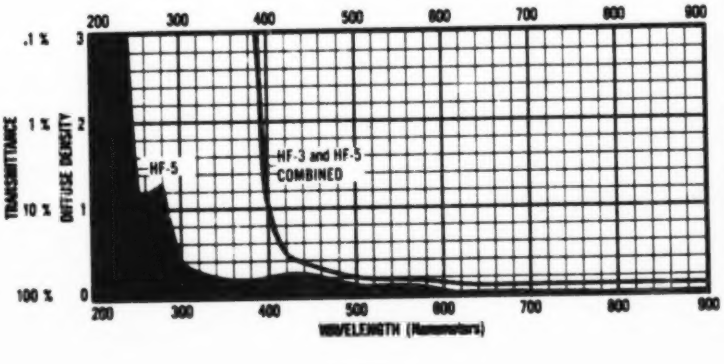
iii) 2443 with 16.

In order to obtain the optical band width B (λ) of each film-filter combination let F(λ) be the transmittance function of the respective filter and S(λ) be the spectral sensitivity function for the particular film. Then

$$B(\lambda) = \int_{\lambda 1}^{\lambda 2} S(\lambda)\ F(\lambda)\ d\lambda.$$

Kodak Ektachrome EF Aerographic Film
SO-397 Development Process EA-5





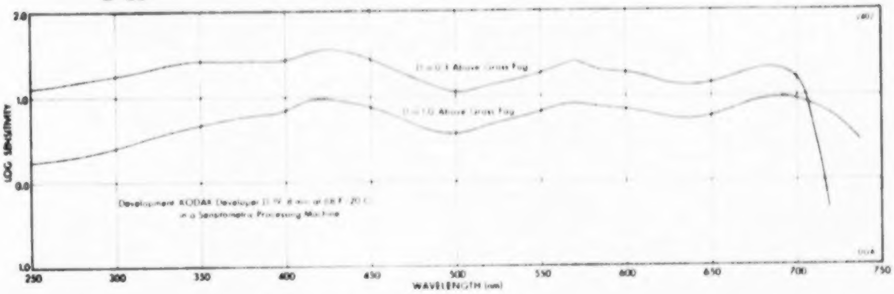
HF-3 and HF-5

AAB*

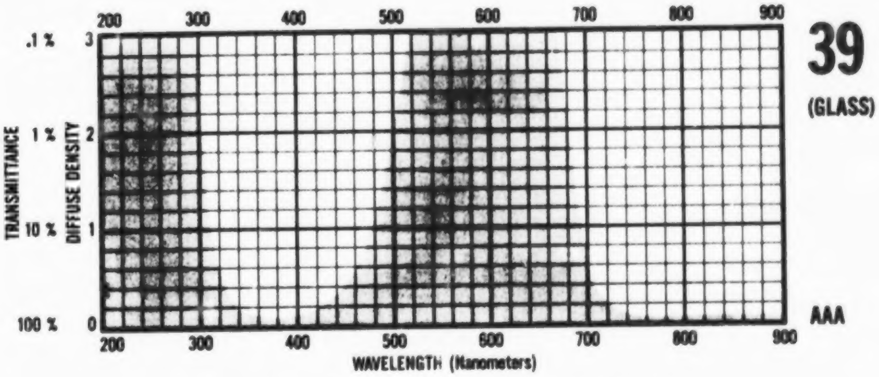
KODAK PLUS-X AEROGRAPHIC Film 2402
(ESTAR Base)

Spectral Sensitivity Curves:

D-19



Sensitivity = Reciprocal of the exposure in ergs/cm² required to produce the indicated density (D) above gross fog.



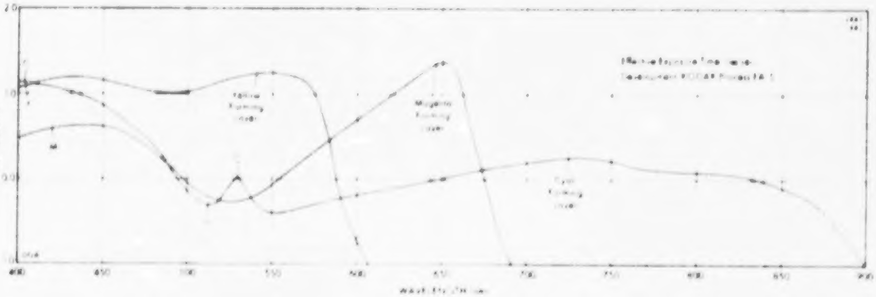
Blue. Glass contrast filter for printing motion-picture duplicates.

KODAK AEROCHROME Infrared Film 2443
(ESTAR Base)

KODAK AEROCHROME Infrared Film 3443
(ESTAR Thin Base)

Critical users of these two films should determine the actual sensitometric characteristics of their particular batch of film by using their own specialized techniques. The keeping conditions for these films have an effect on their sensitometric response.

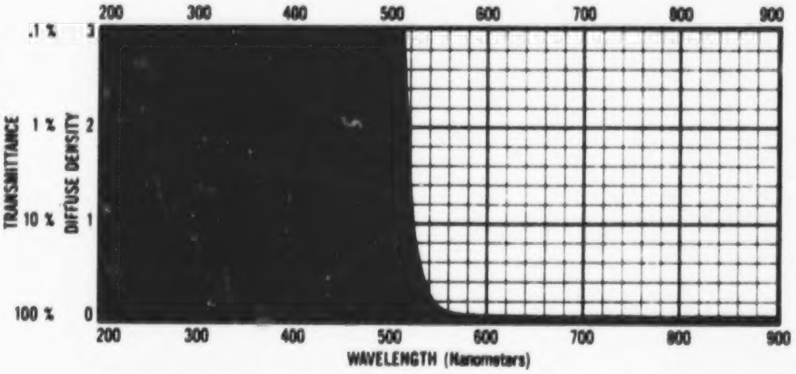
Spectral Sensitivity Curves:



Sensitivity = Reciprocal of the exposure (ergs/cm²) required to produce a density of 1.0 above D min. Measurements were confined to the 400 to 900 nanometer region.

Spectral Dye Density Curves:

16



AAB

Orange. Permits greater overcorrection of sky than No. 15. Absorbs small amount of green.

APPENDIX B

DEVELOPMENT PROCESSES FOR BLACK-WHITE, COLOR RECONNAISSANCE FILMS

The film was processed in processors manufactured by Eastman Kodak Company. The infrared and true-color Ektachrome films were processed in the Ektachrome RT Processor, Model 1811, Type M, Federal Stock Number 6740-109-2987PK, Part Number 460250. This machine uses Kodak EA-5 chemicals. The temperature of the respective chemicals in the processor and the film process rate, in feet per minute, are the important parameters. Their values were specified as follows:

1)	Prehardner	115°F
2)	Neutralizer	115°F
3)	First Developer	115°F
4)	First Stop Bath	115°F
5)	Color Developer	120°F
6)	Second Stop Bath	120°F
7)	Bleach	125°F
8)	Fixer	120°F
9)	Stablizer	120°F

The film process rate was 9 feet per minute. The nine chemical baths, mentioned above, comprise the EA-5 process used for the color films. The temperature and pressure of the fresh water supplied to the processor was 120°F and 45 pounds per square inch minimum respectively. The fresh water is used to wash the film immediately before entering the dryers.

The black and white film 2403 was processed in a Kodak Versamat Model 11-CM processor using Kodak 641 chemicals. This process contains only two chemical baths which are the developer and fixer. During processing, these were maintained at 85°F with a film process rate of 12 feet per minute. Fresh water temperature was maintained at 85°F with a pressure greater than 45 pounds per square inch.

APPENDIX C

Focal Length, Angle of View, and the Effects of Focal Length and Altitude

The focal length of the aerial sensors affects the size (or scale) of the resulting imagery. At any given altitude, the image size changes in direct proportion to changes in focal length. Also for a given focal length, the image size is inversely proportional to the altitude.

The angle of view of a sensor is a function of the focal length and the image format size. The importance of the angle of view is its relationship to the amount of target area recorded in the imagery. Refer to the following diagrams: A. Focal length of a simple lens. B. Effect of focal length on scale and ground coverage. C. Effect of altitude on scale and ground coverage.

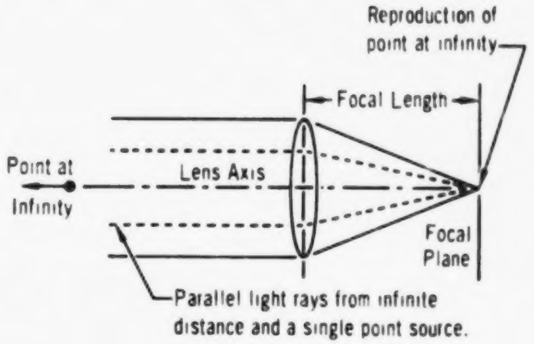

Reproduction of point at infinity
Focal Length
Point at Infinity
Lens Axis
Focal Plane
Parallel light rays from infinite distance and a single point source.

Diagram A. Focal Length of a Simple Lens

Focal length is the distance from the lens (A) to the film (B).

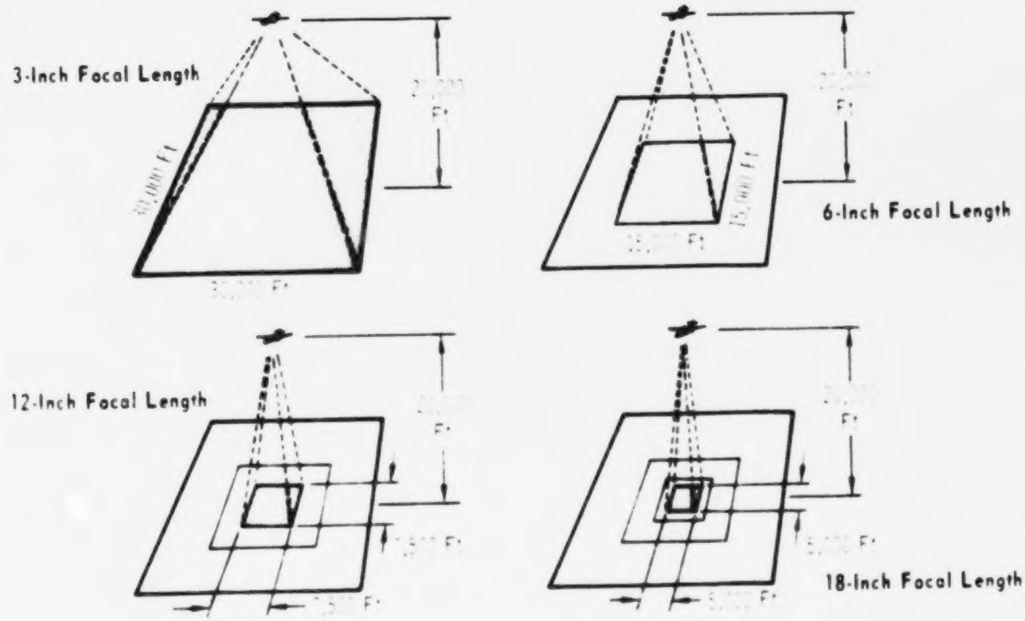
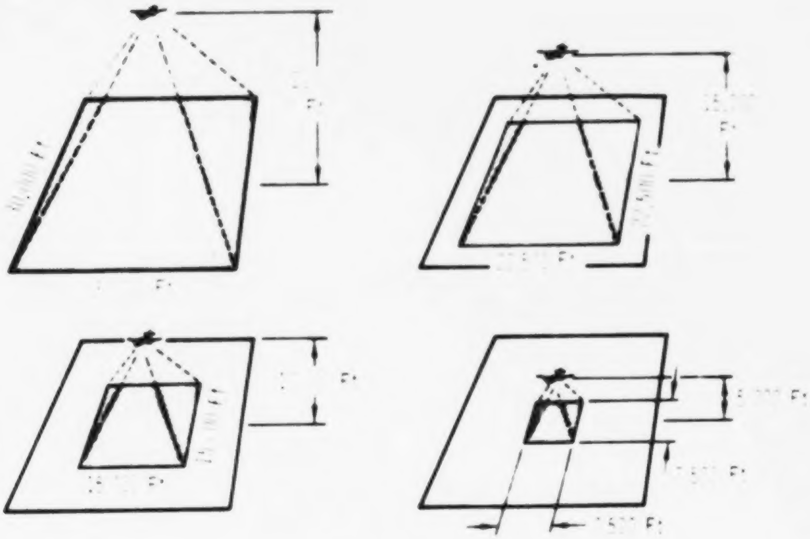

3-Inch Focal Length
20,000 Ft
30,000 Ft
30,000 Ft
6-Inch Focal Length
20,000 Ft
15,000 Ft
15,000 Ft
12-Inch Focal Length
Ft
7,500 Ft
7,500 Ft
20,000 Ft
5,000 Ft
5,000 Ft
18-Inch Focal Length

DIAGRAM B Effect of Focal Length on Scale and Ground Coverage


30,000 Ft
Ft
Ft
Ft
Ft
15,000 Ft
Ft
5,000 Ft
7,500 Ft
7,500 Ft

3-Inch Focal Length

DIAGRAM C Effect of Altitude on Scale and Ground Coverage